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SCHOOL POSTURE AND SEATING

A MANUAL
FOR TEACHERS, PHYSICAL DIRECTORS
AND SCHOOL OFFICIALS

BY

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PREFACE

Increasing use of machinery, specialization of labor, higher standards of comfort and efficiency, have brought it about that most forms of modern activity are done better sitting than otherwise. Our fathers sat to rest from their labors. Increasingly we sit both to labor and to rest. It might be said of sitting, as was said of soap, that its use is a measure of civilization.

Fixed habits of sitting are inevitable. They are bred in the bone and in the muscles. They affect the condition and functioning of the vital organs and in large measure determine one's vigor, energy, resistance to disease. Upon these things depend efficiency, happiness, attitudes toward life. Sitting habits affect all of life's values. They are controllable through knowledge, ideals, and material aids. *Upsitting* should express more of alertness, self-reliance, energy, poise, and power than does *upstanding*, in proportion as sitting enters more into life than does standing.

The habitual sitting posture of most people is distinctly bad. A chair conducive to good posture is a rarity. Much of the seating in public buildings and conveyances makes wholesome sitting impossible. School seats, even those designated as hygienic or posture seats, often violate the fundamentals of posture hygiene. There is a medical literature of scoliosis, a physical-training program for standing and movement, a library of school hygiene; but on the simple matter of wholesome sitting habits there is no adequate literature or organized knowledge.

Such are the reasons for this contribution to a science of sitting and seating. It is made as practical as possible because the need is rather for doing something than for saying something about it. It is focused upon the problems of the school because going to school is among the most sedentary of occupations, because in school permanent habits of sitting are formed, because "what you would have in the life of a people you must first put into the schools," and because educators are the most responsive and responsible group to whom to appeal.

The technical portion of this study was undertaken as a doctor's thesis under the inspiring guidance of Dr. Charles H. Judd at The University of Chicago. Much of the experimental work was done in the training schools of that university, and measurements were made there and in the schools of Des Moines, Cleveland, Philadelphia, and in the New Trier High School at Winnetka. My gratitude for assistance and courtesies is due to so many officials and teachers of these and other schools that I am compelled to forgo the privilege of naming them here.

If this work shall in any measure accomplish its primary purpose of practical service to educators and school children, their indebtedness, like my own, is chiefly to the American Seating Company, without whose liberal spirit and material support it could not have been accomplished. The larger part of the work has been done with means and equipment provided by this company with no restrictions except "Find the facts and let us and the rest of the world know them without any commercial bias or prejudice."

H. E. B.

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NOTE TO THE READER

The reader who desires only to get the main argument, facts, and conclusions of this book will find these presented in continuous sequence in the large print. The illustrations are related to this part of the discussion.

In the condensed print will be found the statistical data and methods of their interpretation, such summaries of comparable studies as seemed justifiable, and the more technical discussions. These will be of interest to the critical student and to the general reader so far as he may desire to follow them out in connection with the particular topics under which they are presented.

The analytical Index and the Contents are arranged with a view to making the subject matter of the book available for ready reference, particularly for school administrators in dealing with the concrete problems on which they must often act quickly.

It is thus hoped that the book will serve both as a practical handbook and as a text about as comprehensive as the subject seems to justify. To accomplish the first of these purposes it has seemed wise to indulge in some repetitions which the systematic reader is asked to pardon.

SCHOOL POSTURE AND SEATING

CHAPTER I

THE SIGNIFICANCE AND SCIENCE OF SITTING

A growing problem. Various are the characterizations of modern life by those who would solve its problems. It is mechanical, it is electrical, it is industrial, it is sanitary, it is moral, it is immoral, it is godless, it is hopelessly complex, according to the point of view. Let us add another: *modern life is sedentary.* The most universal physical occupation of civilized human beings is sitting.

In the main we take our meals, our transportation, our amusements and recreations, and, increasingly, our daily occupations, sitting. Despite strap-hangers' complaints we do most of our "running about" while seated. Even plowing and reaping, ditch-digging, excavating and the lifting of great weights, by the aid of modern machinery, are done mostly by those who sit. Those who are "on their feet" at their customary occupations usually devote more continuous time during their hours of relaxation in a fixed sitting position than they do to any standing position during their working day. Many of us sit during all but a small proportion of our waking hours. More and more modern life is sedentary. There is nothing we do so much or so badly as sitting.

A difficult problem. Those who sit well are so rare as to be conspicuous. Most of us merely slump or sag into our

seats, and the makers of seats seem to have conspired to make it difficult for us to sit as we should. At best they have been slow to recognize and meet the new responsibilities imposed by the rapid spread of the sitting habit. Urban life has entailed its problems of housing, sanitation, and traffic; commercial life, its problems of finance and transportation; industrial life, its problems of safety and welfare; indoor life, its problems of recreation; every change in human habit has introduced difficulties demanding scientific analysis and solution. No less has sedentary life brought its perils, and they can be met not so much by vainly demanding less sitting as by better sitting.

A problem of vital economy. For, physically speaking, as a man sitteth, so is he. By one's sitting is determined the form and development of the skeletal frame and musculature of the trunk, and upon these depend, far more than we realize, the vigor and functioning of the vital organs. Habitual bad posture inevitably means the compression, displacement, and interference with the functioning of thoracic, abdominal, and pelvic organs, and these affect the efficiency, happiness, and length of life. Because these effects are very gradual and subtle, because they are rather predisposing conditions than specific forms of disease, because they are not brought to medical attention until other complicating factors have rendered them acute, they have not had the prominence in medical literature which they deserve; yet their reality and importance are scarcely questioned. If there were no specific pathological effects of bad sitting posture, if there were but a lower level of physical vigor, a lessened zest in living, or merely an inferior comeliness of appearance with its inevitable psychological penalties, the subject would be worthy not merely of a book but of the earnest study of all men. All

these are in the price we pay for bad sitting habits, and these are not nearly all that we pay.

A problem of womanhood. More especially is posture a woman's problem; for women, by their physical nature and the function of maternity, are peculiarly sensitive to these postural perils, and their occupational, domestic, and socially determined habits of life render them especially subject thereto. A great service to humanity will be rendered by one who can effectively make known to womanhood the undoubted relationship between the sufferings and frailties of women and the habitual manner and conditions of their sitting.

A problem of childhood. Even more is posture a problem of childhood, for civilization has imposed upon the child one of the most distinctly sedentary occupations yet devised. At whatever age, whether we will or no, long-continued hours of sitting do develop posture habits of some sort, good or bad. In the case of the child, whose skeletal framework is yet plastic and progressively acquiring its permanent form from the pressures and strains to which it is subjected, whose muscular equipment is developing in accordance with the demands made upon it, whose physical as well as mental habits are acquiring their permanent set in the nervous system, the postural tendencies which school life imposes are an inevitable part of the educational determinants for weal or woe which childhood bequeaths to maturity. Whatever studies of posture may disclose, they are primarily matters that concern the schools. Responsibility for the right education of children involves a very large responsibility for the understanding and control of the influences which determine postural habits. Undoubtedly the tree grows as the twig is bent, and that human twigs are being ruthlessly bent with little regard

to causes or consequences a study of the postures of children in almost any school will demonstrate.

A controllable situation. Postural habits are controllable. They are as definitely subject to educational direction as are habits of language, of thought, of manners, of conduct, or other objectives in teaching. There are individual differences and environmental influences to be considered as in other forms of training. (The technique of teaching posture, particularly as relates to sitting, has had little systematic analysis or constructive study. Curiously enough, teachers of physical training have considered the subject mainly from the angle of standing posture or of carriage and movement. And here they have proved their efficiency by their results. Yet standing of a sufficiently continuous sort to affect form and development is rare, whereas sitting which actually determines the growth of muscles and bones is universal. An interesting fact is that innumerable school children stand beautifully erect, only to slump into a distressingly unhygienic position as soon as they sit. They stand for moments but sit for hours. The very condition of standing is a fair degree of erect poise, for most of us would topple over if we stooped as badly in standing as we do in sitting.)

A national ideal. That posture can be taught is a commonplace of military training. Soldierly erectness or the bookkeeper's stoop are alike results of controllable influences. Neither is inherited nor, barring deformities, due to original variations of physical structure. Many are the occupations which leave their indelible marks for good or bad in the form of habitual posture and carriage. Each of us has his own characteristic sitting, standing, and walking habits which are the

result of some combination of educational, occupational, psychological, or mechanical influences. In every case some combination of causes has made us erect or stoop-shouldered, full-chested and soldierly or hollow-chested, round-backed and ungainly. When these causes are thoroughly understood, they can be controlled. Is it not reasonable that when we have achieved a thorough analysis of the contributing factors and a widespread dissemination of knowledge and interest in the matter, there may be gradually brought about a higher national standard of posture, with the inevitable general improvement of health, vigor, efficiency, and better appearance — an upstanding and upsitting nation?

Posture and efficiency. Certain progressive industrial organizations have already made careful motion studies of their employees and, by the introduction of improved seating with suitable rearrangement of machines, lighting, etc., have got increased output as a direct result of improved posture and consequent greater efficiency of the workers. Similar gains are possible in the life economy of any individual. Each of us can increase his output of the values of life — whether of work, rest, enjoyment, or good cheer — by securing the conditions and mastering the technique of wholesome sitting. There is scarce room for doubt that there is a definite relationship between the manner in which one habitually sits at his desk and his working attitudes, energy, and efficiency. In the schools the influence of posture upon success in penmanship and some other motor activities has been studied with positive results. In purely mental work the totality of causative factors and of educational results is so complex that the relation between posture and efficiency is difficult to demonstrate in arithmetical

fashion, yet the fact can hardly be questioned. There is a challenge here for statistically minded students to find the correlation between individual posture and efficiency in school work. There will be little disagreement on the assumption that an alert physical attitude denotes and contributes to a correspondingly tense mental condition; or that capacity for sustained mental activity is immediately dependent on an abundant supply of oxygen, on the rapid elimination of toxins from the system, and on other wholesome physiological conditions, and that these are conditioned by a posture favorable for vigorous vital processes.

Posture psychology. A director of physical training in a great university recently said that in his opinion erect posture is to be esteemed as much for its social and psychological suggestion as for its direct hygienic value. There is a self-respect and self-reliance incident to erect posture and carriage which go far toward making one worthy of the respect and reliance of others. The belief that soldierly bearing develops soldierly qualities is basic in military training. One squares his shoulders and stiffens his spine when he exercises those moral traits with which these physical attitudes correspond, and mental habits of such sort are almost inseparable from the physical ones. The world has always judged the character of people from their physical bearing, and so far as that bearing is habitual the judgment has proved reliable. There is an interesting field of study to be developed in checking posture characteristics against character traits as indicated by "will-temperament" tests and other indexes.

Whether for physical hygiene, for mental efficiency, for social and character values, or merely for the sake of personal appearance, there can be no doubt but that pos-

ture and its control are well worthy of scientific investigation. The present study has been undertaken in the firm faith that it is worth while for all these reasons and that a more general knowledge of the subject will contribute to improving the general health, vigor, and efficiency.

Posture and seating. Sedentary school posture passes from a speculative to a very vital interest when we consider its bearing on permanent health and present efficiency. It comes out of the clouds of educational theory to the solid ground of practical procedure when we discover that it is the direct outgrowth of the sitting and of the seating in the schoolroom, that it is a question of dimensions of wood and steel, of angles of illumination and the arrangement of seats, of the scoop in the seat, the curve in the back, and the slope of the desk top. It is with these very practical aspects of the matter that this book is chiefly concerned.

Seating reforms now needed. Great hygienic reforms have usually been astonishingly simple and obvious after they are appreciated, although a deluge of books, expert opinion, propaganda, and campaigning was necessary to get them appreciated. Witness the drives in behalf of fresh air, pure water, exercise, cleanliness, and simple food. The most urgent reforms in seating are in a similar case. They are almost absurdly simple and obvious, but it will take a deal of strenuous propaganda to get them recognized and heeded. Everyone agrees when attention is called to the reforms needed, but few feel that the responsibility is theirs to do anything about it, and no one can undertake to find and convince all those upon whom the responsibility rests.

Approximately in the order of their urgency the reforms needed in school seating may be stated in all

their nude simplicity thus: (1) lower seats in all grades; (2) shorter seats, in most cases; (3) less backs — lower at the top and higher at the bottom; (4) simple but more rational forms of seats and backs; (5) lower tops and closer spacing of desks; (6) arrangement according to well-known but sadly neglected principles of lighting; (7) the adjusting of seats that are adjustable and the moving of those that are movable (intelligently, to be sure, but quite simply); (8) appreciation of the sanitary, æsthetic, and structural excellences which are available; (9) selection according to the diverse requirements of varying grades and uses; (10) buying with the same foresight and intelligence that is applied to the purchase of other things.

The needed reforms are almost as simple as that. Expert advice will indeed be necessary to interpret these requirements and to avoid swinging from one error into another. Detailed applications must be worked out on the basis of scientific study and wide knowledge, even as sanitary experts are essential to the simplest community cleanliness. But the objectives are neither abstruse nor recondite. They are obvious and easily attained. They cost nothing in the long run and pay large returns. The succeeding chapters have sought to make an original contribution to the practically new field of a seating science, with the hope that it may be developed by subsequent studies into an important body of knowledge; but their primary aim is the very practical one of emphasizing the immediate need of a few very simple and obvious reforms in the hope of direct results.

CHAPTER II

SKELETAL MECHANICS OF SITTING

An astonishing mechanical device. Consider a column designed for sustaining weights, composed of numerous short segments separated by elastic pads, complexly curved throughout its length and flexible in every direction, set upon a base that is normally sloped and that turns and moves in every possible way; and yet it is a column capable of carrying heavy loads whether poised squarely upon it, swung to any side, or shifting about. Such is the vertebral column, by which erect position of the human trunk is possible. The column consists of twenty-four short plinths of bone (vertebræ) set one upon another with pads of elastic cartilage between them. Like so many blocks of wood set endwise with felt pads between, the column can resist enormous pressures longitudinally so long as the strain passes directly through each unit and does not become a sidewise or buckling thrust. To the extent that the latter occurs the strain must be met by the ligaments and muscles which bind the segments of the column together. It is because of the flexibility of the column and the mobility of the base that the column can be adjusted to serve its supporting function under loads variously placed. A great weight may be carried with ease so long as the skeleton forms a true support beneath it, while a very much less weight will rupture the muscles and tendons of the back if the spine loses its columnar alignment. Ability to carry

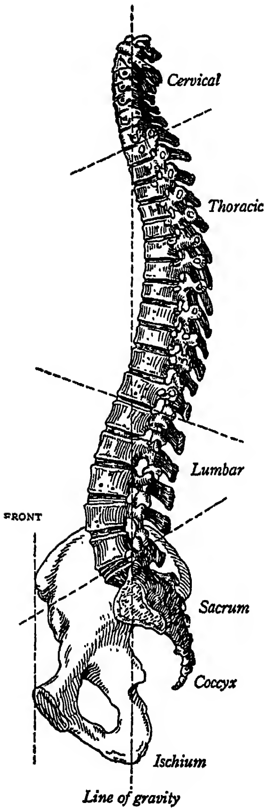


FIG. 1. Spinal column in erect posture. This shows its support upon the sacrum and (the right) innominate bone. Observe the angle formed by the top of the sacrum; the cervical, thoracic, and lumbar curves; and the position of the line of gravity

weights is not so much muscular power as it is skill in keeping the spinal poise.

Furthermore, bone and cartilage are practically insensitive to strain or fatigue, and the back is tireless to the extent that the vertebral column rather than the muscles sustains the load. Hence the problem of sustaining weights or of maintaining erect posture for a long time is a matter of controlling the curvature of the spine, so that it functions as a true supporting column rather than as a mere leverage for the muscles.

The pelvic framework. To appreciate how this very complex structure can serve as a column for sustaining weights, we must examine in some detail the base on which it rests. This base is the *sacrum*, a wedge-shaped bone rigidly locked into the solid frame of the pelvis. (Figs. 1 and 2.)

The *sacrum* is really a continuation of the spine and in infancy consists of five distinct vertebræ, which gradually solidify until, by the age of twenty-five, they form a single bone. It serves to unite the *ilia* (hip bones), to form the rear wall of the pelvis

(Fig. 2), and to support the spine (Fig. 1). The name of this bone is of interest, being Latin for a sacred or holy object. It was actually used in pagan religious ceremonies and apparently because the early anatomists recognized that in its peculiar development in man is found the key to that distinctively human attribute, erect posture and carriage. In contrast, the rudimentary and apparently functionless tail bone (consisting of four or five rudimentary vertebræ suspended from the sacrum) is called the *coccyx* (cuckoo) because of its fancied resemblance to the beak of that bird of ill repute.

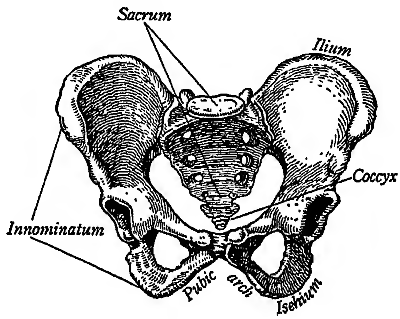


FIG. 2. Bony structure of the pelvis. Front view

The framework of the pelvis (Fig. 2) consists of the two great bones called the *innominata* (meaning "nameless," because they resemble nothing whatsoever), which are powerfully locked together at the rear by the sacrum and in front by the *pubic arch*. The bases of the pelvis are the rounded lower sections called the *ischia*, and they rest upon thick and rather spongy edges called the *ischial tuberosities*. These tuberosities of the ischia are the bones upon which we sit, and they are shaped and function very much like the rockers of a rocking chair. Just above them are the deep sockets in which the thigh bones are inserted with "ball-and-socket joints." The downward thrust of any weight carried by the spine is transmitted through the sacrum and the solid pelvic frame directly to the seat support at the ischial tuberosities or in precisely the same manner to the legs at the thigh sockets.

The pelvic cavities. The pelvis is as important for its protecting as for its supporting functions. The wide-spreading upper or wing-like portions (the *ilia*, or hip bones) form a large, forward-tilting bowl which supports the intestines (Fig. 2). At the bottom of this bowl is an opening (the *pelvic neck*) of less than half its diameter, which connects with the lower, or true, pelvic cavity.

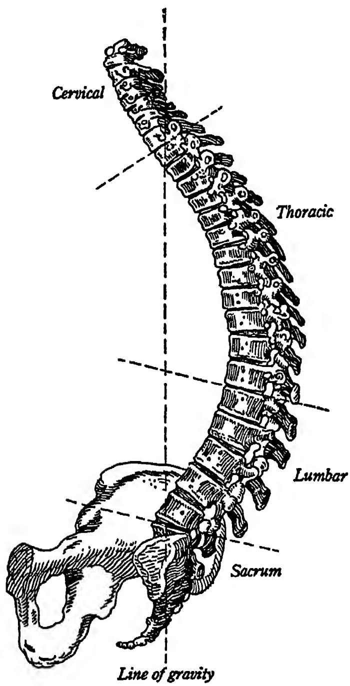


FIG. 3. Spine in stooped posture

The slope of this pelvic bowl, together with the forward projection of the overhanging lower vertebræ and the upward lift of the abdominal muscles, forms a most effective protection which prevents the weight of the lower intestines from pushing down into the pelvic neck *so long as the pelvis is in erect position* as in Fig. 1; but when the pelvis is tilted backward as in Fig. 3 this protection is lost and the overhanging weight pushes directly down into the upturned neck.

The spine in posture. When one sits erect with the spine in the position shown in Fig. 1, the line of gravity about which the weight of the upper body is balanced lies almost wholly within the vertebral column, passing through the sacrum, on which it rests, and the ischia, which support the load upon the seat. Thus the body weight is carried by an untiring bony framework without mus-

cular exertion. But in stooped posture, when the pelvis is tilted backward as in Fig. 3, the line of gravity through the sacrum falls far behind the ischia; the foundation is no longer under the structure. The downward pressure along the line of gravity accelerates the forward sliding of the ischia and the backward tilting of the pelvis until the weight rests upon the yielding coccyx, which is simply pushed up into the lower pelvic cavity.

In erect position the top of the sacrum slopes forward at an angle of about thirty degrees and the *lumbar vertebræ* form a decided forward curve (the *lumbar concavity*) (Fig. 1), while in stooped posture the top of the sacrum becomes level or slopes backward, thus making the lumbar curve straight or convex (Fig. 3), compressing the cartilaginous pads on the forward side, and stretching them and the ligamentary connections on the posterior side. This change necessitates a sharp forward bending of the entire upper spine and head in order to preserve the balance, and the spine (including the sacrum), instead of being a succession of four alternating and compensating curves (Fig. 1), is a single convexity from head to seat (Fig. 3). So far from being a supporting column in this position, the spine has the form of a bow across which the line of gravity runs like the string. The upper weight, instead of being supported by the column, tends to buckle the spine and pull it apart, and must be carried by pressure on the vital organs in front and by straining at a mechanical disadvantage on the overstretched back muscles behind. This position, which we refer to as *stoop, slump*, or *sag*, is conducive to many ills and injuries and is in every respect weak, inefficient, unwholesome, and ungainly.

This single convex curve is the form of the spine of an infant at and before birth, the vertebræ being still mostly cartilage. As ossification (bone formation) progresses, the ability to hold up the head develops with and depends on the formation of the forward bend in the neck (*cervical*) vertebræ, and the ability to hold the trunk erect depends similarly on developing a lumbar concavity. The ribs are attached to the twelve thoracic vertebræ, and together they form a relatively inflexible frame, the columnar portion of which is always slightly convex. Hence, for the entire spine to take an approximately straight columnar form, there must be concave curves in the cervical and lumbar levels. To appreciate the mechanical perfection of the vertebral column, one must keep in mind not only the bracing of the thoracic vertebræ by the whole thoracic basket of the ribs and their attachments, but also the forward and downward pull of the arms from their suspension at the shoulder blades behind the thoracic bend.

It seems to be a general opinion that the spinal column is literally a "backbone" and somehow "runs up the back" with chest and abdomen hanging forward from it. In fact, however, the column is centrally situated in the trunk. It is normally forward of the center of the body at the level of the hips, and the face of the fourth thoracic vertebra is precisely at the center of a cross section of the trunk at that level.

The bony points felt along the back are the *spine-like* protuberances which project far behind the column, which serve for interlocking the vertebræ and attaching the tendons and ligaments, and give its name to the column. The ribs attach at the rear of the vertebræ and extend still farther back before turning to encircle the lungs, and the shoulder blades and muscles are quite behind the ribs; and at the lumbar level thick masses of muscles and tendons are packed about the long spines behind the vertebræ of the column. A recognition of this central position of the vertebral column is essential to an appreciation of its function in bodily poise and posture.

Plasticity of the skeleton in the young. In infancy the entire skeletal structure is largely cartilaginous and pli-

able. Then the pelvis consists of six loosely articulated bones besides the five which, as we have seen, later form the sacrum. The vertebræ are mainly elastic pads of cartilage, the skull has its soft spots, and the leg bones are easily deformed by early strains. The extreme susceptibility of the bony parts to distortion through persistent pressure is well illustrated in the former customs of confining the feet of Chinese girls and the skulls of Flathead infants. At all ages the bones are more easily and permanently modified by continuous pressure than are the other and softer parts of the body, and during childhood their susceptibility to malformation is almost limitless. By the age of twenty-five ossification is practically complete, and the bones have taken the forms which they will normally maintain through life. During this period of progressive ossification, which is almost precisely the period of school life, whatever influences can normally affect the shaping of the skeletal frame are accomplishing their permanent work for good or ill. Habits of good posture which are literally "bred in the bone" in this period are not likely to fail in later years, nor are bad postural habits so bred easily overcome.

Skeletal requirements in posture and seating. Regarded, then, in the light of the wholesome development and the maximum efficiency of the bony framework, the posture which should be made habitual is that in which the spine functions as a true supporting column, balanced about the line of gravity as in Fig. 1 and with the weight distributed around it. This is possible only when the pelvic frame is erectly poised on the ischial tuberosities (or on the thigh bones in their sockets, if one is standing), which mechanically necessitates a

forward tilt of the sacrum and preservation of the lumbar concavity. As will appear later with increasing clearness, the type of seat favorable to this posture is that which facilitates a backward rather than a forward sliding of the ischials on the seat and which provides back support at the lumbar and lower thoracic levels and not against the pelvis or the shoulders. Further development of these conclusions requires an investigation of the muscular factors involved.

CHAPTER III

MUSCULAR FACTORS IN SITTING ERECT

The sitting muscles. The principal muscles used in sitting erect are the long back muscles (*erectores spinæ*), which are inserted on the posterior surface of the sacrum and attached at various levels to the thoracic vertebræ and ribs (Fig. 4). Their contraction tends to draw toward each other the sacrum and upper portion of the back. This keeps the pelvis erect and the top of the sacrum tilted forward, and maintains the forward curve at the lumbar level of the spine, and, by drawing down the back, expands the chest. In a similar manner the muscles of the neck hold the head erect and preserve the forward curve of the cervical vertebræ. There is also an important pair of fan-shaped muscles (*trapezius*), which draw the shoulder blades down against the back. The combined action of these three groups of muscles insures the position of the skeleton described as erect in the preceding chapter and presents externally what we recognize as a well-poised military posture. This is what occurs when one "straightens up" his back in sitting or standing.

The whole process is, of course, far from being so simple. The intercostal muscles, which lift the ribs and expand the thorax, and the broad bands of abdominal muscles, which draw the abdominal walls up and back toward their origins on the spine and lower ribs, are brought into play in erect posture. The great *psoas* and *quadrati lumborum*, which attach at the sides

of the upper lumbar vertebræ and pass down through the pelvis to the thighs, help to draw the hips forward and preserve the forward bend of the spine at the lumbar level.

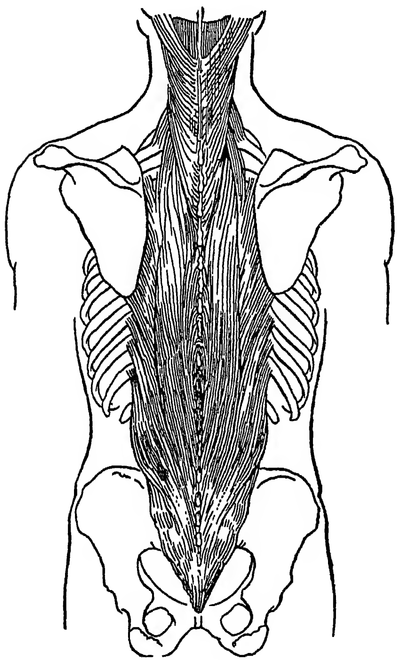


FIG. 4. General view of the long muscles of the back. They originate at all cervical and thoracic levels, form a thick mass of tendinous flesh at the lumbar level, and insert on the posterior surface of the sacrum

A comprehensive treatment of postural kinesiology would also consider the action of all these muscles as antagonistic pairs and groups. In the interest of brevity only dominant groups are mentioned here.

Posture and muscular contraction. Erect posture is, then, almost wholly a problem of keeping these groups of back muscles short. But this does not mean that they must be continuously in active and fatiguing contraction. Once the trunk is erectly poised and balanced about its bony support, it is only necessary that the muscles be kept in that "mild degree of sustained contraction" known as *tonus* or tonicity, an alert condition just sufficient to keep the poise and ready to check the slightest tendency to topple out of balance. The bones carry the weight, and the muscles serve merely to steady it. The nature of

this muscular tonus is apparent through its loss when one nods while dozing in an upright position. He was not previously conscious of any exertion involved in poising the head upon the neck vertebræ, but the complete relaxation of the neck muscles permits the head to fall forward. The trunk would fall similarly with the relaxing of the tonus if it were not supported by the chair or otherwise. It is entirely practicable, however, if proper back support is provided, for one to remain sitting perfectly erect with the back muscles completely relaxed. When one does so, these muscles remain shortened and retain their tonicity without actual exercise or fatigue. Muscles are much like rubber bands in that if kept short they retain their elasticity, but if kept stretched they lose their contractility and can function in the shortened position only with great difficulty or not at all. Now in stooped or slumped posture (Figs. 3 and 6) the back muscles are stretched to much greater length than when the back is erect. If the stoop is persisted in, not only does the spine lose the form which favors erect poise, but the muscles lose the contractility necessary to hold it erect. Posture habits, therefore, are not only "bred in the bone" but are woven into the very fibers of the muscles. Erect posture means short and strong back muscles; habitual stoop inevitably makes them long and flabby.

The question is sometimes raised whether pupils in school should not, as a means of strengthening the back muscles, be required to sit in seats without backs or with those so placed as to be very little used. If they really and invariably sit erect, the muscles in question would undoubtedly get more exercise and acquire more strength. Even were this assured, the price paid in discomfort, painful fatigue, distraction, and interference with mental activities for this accession of strength would be

out of proportion to its value, since the tonicity preserved by sitting erect with support is adequate for posture purposes, and back strength for other purposes is probably a different thing, better acquired in other ways. But the inescapable fact is that pupils do not and probably cannot sit erect during the long hours of school work without support, and the lack of proper support results in stoop with its accompanying stretched and flabby muscles.

The shoulders in posture. When the trunk is erect, the shoulders of their own weight hang down and backward, as a result of which the collar bone, breastbone, and ribs are lifted and the chest is expanded. This tendency is increased by the contraction of the trapezius muscles, which draw the shoulder blades down against the back. The shortened condition and tonus of these muscles is an essential part of erectness, and for this purpose they act as part of the whole muscular system of the back. In the stooped or slumped posture the shoulders hang forward, contracting and depressing the chest. So intimately is the posture of the shoulders related to that of the spine that either will serve as a reliable index of or an efficient cause of the other. A high desk, which requires the elbows to be raised out and forward in order to write upon it, by this fact causes the spine to fall into a stoop. Similarly a deeply rounded back support, which pushes the shoulders forward, inevitably causes the spine to slump. On the other hand, a most effective way to bring the spine of a child into erect position is by gently pressing the shoulders back and down.

Good posture and the chair back. The only "correct posture" chair is that in which one may *relax the muscles completely and remain erect* with the pelvis vertical, lumbar curve preserved, shoulders hanging back and

down, and chest and abdomen expanded. If one of these characteristics of erectness occurs, the others are normally certain to accompany it. If any one is lacking, the others are practically impossible. The back support which is essential to maintaining this position with muscles relaxed is that shown by the lower support in Fig. 5, which supports the lumbar vertebræ above the hips — the area known as the "small of the back." By leaning very slightly against this every muscle (except those sustaining the head) may relax, and the trunk may retain its poise and the back muscles their shortness and tonicity. Narrow support at this level only, however, would involve a very dangerous strain on the spine, and a pressure on the kidneys in case the upper weight should be thrown a little farther back. Hence a supplementary support sufficiently high to avoid any back-breaking strain is imperatively necessary. It is also necessary for comfort.

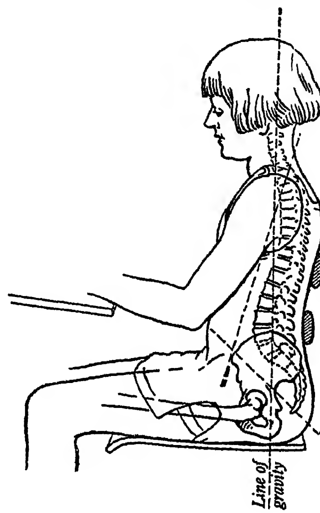


FIG. 5. Erect posture, showing body poise and lumbar curve sustained by well-placed back supports. Note the angle formed by the dotted lines indicating the center lines of the main trunk and pelvic cavities. Compare Fig. 6

The mechanical reasons for the lumbar support are obvious. This is the point of greatest flexibility, where nearly all the bending in stoop occurs, as well as the region of the greatest thickness and contractility of the back muscles. Support here

checks the stooping tendency at its beginning, before its accelerating leverage has developed. It is the point of longest leverage for keeping the pelvis erect, and hence does so with least pressure. The muscles serve as a cushion against the support while being held in tonicity without exertion.

Support against the pelvic frame at the level of the sacrum provides no support whatever for the flexible portion of the spine and also functions as a fulcrum against which the whole upper weight acts as a lever to force the ischials forward on the seat. Support against the shoulders merely prevents the trunk from falling backward, but offers no check to the sagging of the spine below it into stooped posture. Any back support made in a straight line, whatever its slope, makes contact above and below the lumbar curve, and hence does not check the stooping tendency until the pelvis has tilted backward out of equilibrium, the lumbar curve has reverted to a straight line, and the process of sliding down into a slump has begun. The effect of a back of this type when one relaxes against it is the stooped posture illustrated in Fig. 6.

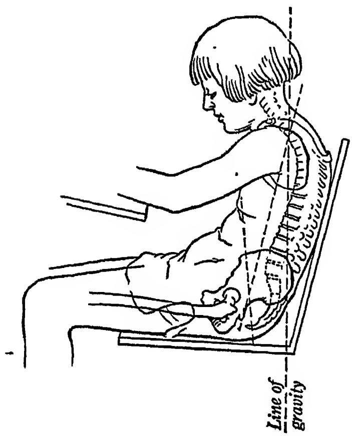


FIG. 6. Stooped posture resulting from relaxation against improper back support. Note angle formed between center lines of trunk and pelvic cavities

Thighs and buttocks. The muscles of the thighs and buttocks are largely involved in standing posture, though they do not function directly in holding the trunk erect. Their importance in sitting is for other reasons. The thick pads of muscle (gluteal, or *gluteus maximus*) which form the buttocks are used in walking (particu-

larly on an incline) but are relaxed in sitting. They do not serve as a cushion, since any pressure from below merely pushes them up against the coccyx and into the lower pelvis. If they come in contact with the back support, to that extent they prevent its fitting into the lumbar curve. Hence there should be no elevation of the seat at the rear nor any continuation of the back support below the hips to come in contact with these muscles. Individuals differ so much in the size of these muscles that it is impracticable to form a back support to fit around them.

Under the thighs the thick pads of muscles (*leg biceps* and associated groups) do serve in some measure as cushions to relieve the ischial bones of some of the body weight. The bones themselves require no relief and are never fatigued, but the tissues under them may become tiresomely pinched between the bones and a hard seat. Furthermore, the mere shifting of a portion of the weight forward and backward along the thighs brings about a wholesome change of muscular adjustments and tensions and thus avoids fatigue. It is important to note that these muscles are thick under the upper half of the thighs, tapering to mere tendons in the area (*popliteal*) behind the knees. In this latter area and also in that immediately forward of the ischial bones (the line at which the flesh folds in when one stands) there are no protecting muscular pads, the tendons are relaxed in sitting, and there is no protection against external pressures for the nerves and blood vessels which pass these points between the thigh bones and the seat. It is therefore of primary importance that there should be no pressure from a hard seat-bed in either of these regions. Furthermore, as a simple

matter of leverage, no support under the lower part of the thigh can carry body weight, since it merely tends to lift the knees and support the weight of legs and feet, which should rest on the floor. This subject will be developed more fully in later chapters, but obvious conclusions which may be stated here are that the seat should be short enough and low enough so that there will be no pressure in the (popliteal) area behind the knees.

It has often been stated that the problem of erect poise is one of keeping the trunk in stable equilibrium by having the line of gravity fall within the base formed by the ischial bones and the thighs in sitting or by the feet in standing. This is pertinent to posture only upon the assumption that the upper body is kept rigid with reference to the thighs by means of the active contraction of the muscles about the hips. It is equally true of the most pronounced stoop and hence is irrelevant to erectness. The only support for the body in sitting is the ischial tuberosities; the only support in standing is the thigh sockets; and about the lines of these supports the trunk moves freely as on a hinge joint. No broader base is possible except by tying the hips to the thighs through muscular rigidity, and then there still remains the problem of maintaining the erectness of the trunk. Even that support of body weight from the thigh muscles which has been referred to in the preceding paragraph implies muscular action about the hips to make it effective, since otherwise the only effect would be to lift the legs. The matter is quite distinct from the maintenance of erect posture, which assumes weight support only at the ischials and steadying support against the lumbar vertebræ.

The slope and conformation of the seat which insure that the ischials shall rest as far back as necessary to secure correct lumbar support for each individual who shall make use of a seat, the wide variations among individuals in the relative position of these points, and the futility of any "form-fitting" scoop are reserved for discussion in Chapter XIII.

Standing posture. Erectness of the trunk in standing is essentially the same as in sitting, support being from the thigh sockets instead of from the ischials. The muscular activity involved in standing is much greater, since the hip, knee, and ankle joints as well as the spinal curves must be controlled. With all the postural defects in our standing, to which physical culture has given much attention, we cannot stand as badly as we sit. If one should attempt to stand with the body stooped as indicated by Fig. 3, or slumped as in Fig. 6, he would simply fall over; and yet these are very common and characteristic sitting postures of those who habitually stand quite erect. It is probable that if erect sitting is habitual, erect standing is a natural consequence. The reverse is certainly not true.

CHAPTER IV

POSTURE IN RELATION TO VISCERAL SUPPORT

Some problems of erectness. The transition from the horizontal to the vertical habit of life involves a striking series of adaptations for the support and protection of the viscera, or soft organs of the body. In the quadruped these large organs are supported directly from the spine by the basket-like thoracic framework and the bag-like abdominal walls. There is no tendency to displacement through the action of gravity or any position which the animal characteristically assumes. In the vertical position of man, however, the direct supporting function of the ribs and abdominal walls is lost, and the organs tend to fall downward, piling their accumulated weight upon the nethermost. This tendency is complicated by the skeletal and muscular difficulties of maintaining erect position already discussed. The slumping or stooping posture adds the weight of the head, shoulders, and spine to the downward pressure upon the viscera. The chest is mechanically flattened and the thoracic organs are squeezed downward while the pelvis is pushing up against them from below.

Nature's solution. There is, however, a series of supporting arrangements remarkably adapted to sustaining the internal organs while the body is in erect posture.[1]

[1] Dr. Joel E. Goldthwait, "The Relation of Posture to Human Efficiency and the Influence of Poise upon the Support and Function of the Viscera," *Boston Medical and Surgical Journal* (1909), Vol. CLXI, pp. 839–848.

The human trunk is very far from being like a vertical bag stiffened on the back side by the spine, as might easily be inferred from a superficial knowledge of its anatomy. It is rather a series of shelves and basket-like or pocket-like devices nicely distributed and balanced round the spinal support, so that when posture is erect the visceral burden is carried by strong supports from below rather than suspended from above or loosely piled together. To appreciate this we must keep in mind the fact that the spinal column is not at the back but is centrally placed. The column at the level of the hips is forward of the center of the body. The space at its sides here is filled by the large *psoas* and *quadrati lumborum* muscles, and the movable viscera lie mostly forward of the vertebræ. At the level of the eighth thoracic vertebra a cross section shows the vertebra still well in the center of the body with the ribs curving sharply backward from it, providing space for the liver and lungs to be balanced about it and for the heart and stomach to be shelved upon its forward sloping curve.

Normal visceral supports. With this general idea in mind we may look more particularly at the several supports, beginning from below with the pelvis. The pelvic bowl (in erect position) is tilted forward and downward from the top of the sacrum at about 60 degrees from the horizontal. With its pubic arch it forms a rigid support which carries the major weight of the intestines without muscular or neural strain. The broad girths of abdominal muscles hold this weight against the pelvic support as well as upward and back toward their origin on the spine and lower ribs. Because of the overhanging lumbar curve the intestines are thus kept pushed forward and prevented from crowding down upon the

bladder and genital organs, which lie in the pelvic neck, and, by contraction of the abdominal muscles, are lifted quite clear of these delicate lower organs.

The insertion of the great thigh muscles (psoas and quadrati lumborum) on the upper lumbar and lower thoracic vertebræ affords on either side a muscular shelf upon which the kidneys are cosily nested in fatty tissues.

The liver is drawn well around to the right side of the spine and rests upon the kidney and its firm shelving and upon the forward curve of the lumbar vertebræ. It is held against these by the combined action of the abdominal muscles and the lower ribs, which grasp it quite like protecting fingers.

The stomach, when weighted with its contents, is similarly held by the ribs of the left side and by abdominal muscles against the forward bend of the lumbar curve of the spine.

Stretched like a conical tent over these abdominal organs is the diaphragm — a tendinous-muscular partition attached forward and above at the *sternum* (breastbone) and below, round the sides and back, to the ribs and body wall. It thus forms deep side-pockets in which the lungs are held up against the hollow sides and back of the thoracic cavity (which the Germans appropriately call the *Brustkorb*, or breast basket). The diaphragm, together with the ribs, also holds the weight of the heart against the central spinal support.

Thus all the heavy, movable organs are upheld by a series of pocket-like, basket-like, or shelf-like supports which are substantially attached to and balanced about the spine *so long as it is in erect position* with the lumbar curve well preserved. All these organs are also protected by their own membranous coverings and attachments;

but these are delicate and easily ruptured tissues, entirely lacking in muscular strength, contractility, or capacity to sustain the organs in place.

Failure of supports in stooped posture. In erect posture the central line of the body cavity (Fig. 5) slopes forward at an angle of about 25 degrees from the base of the neck vertebræ to the pubis, while the central line of the pelvic cavity slopes forward and upward at about 45 degrees from the end of the coccyx to the umbilicus (navel). In a stooped posture, however, as the shoulders project forward and the pelvis rotates backward, these two central lines approach a single straight line (Fig. 6), and the downward thrust of the viscera with the superimposed weight and pressure is forced directly into the upturned pelvic neck. The protective overhang of the lumbar vertebræ is removed, and the weight of the intestines is dumped backward from the pubis upon the genital organs. The abdominal walls become loose so that they cannot lift the intestinal weight, and, besides, there is no available space above into which to lift it. The kidneys and liver are literally shoved off their supporting shelves, while the protecting muscles and floating ribs spread away from them so that they must be carried by their own delicate membranous coverings, the stretching or rupture of which results in "floating" kidneys and liver.

Meanwhile the sternum (breastbone) is brought down and inward by the depression of the upper ribs, and the thoracic organs push downward upon stomach and liver, which are no longer sustained by the abdominal muscles, ribs, or under-shelving curve of the spine. By the forward position of shoulders and thorax, the lungs and heart are dumped off their body wall and spinal supports upon the now relaxed and yielding diaphragm, and the

contraction of the bony thoracic frame powerfully forces these organs down upon those below them and tends to rupture their delicate membranes and attachments. The weight of the head and arms is added to the force which is crowding upon or leaning upon the viscera. Thus all the organs have lost their natural substantial supports and are more or less dumped and jammed down upon each other in an unbroken line from the shoulders through the pelvic neck.

Posture and female disorders. The female pelvis is broad and shallow, and the pelvic neck relatively wide. Because of its child-bearing function the uterus is capable of great distention and movement. It normally lies horizontally forward from the upper extremity of the vaginal opening at the level of the pelvic neck. Loops of the smaller intestine lie loosely about it. Pressure from above upon these intestines causes them to shove the uterus back (retroflexion) and into a vertical position over the vaginal opening and then down into that opening, producing ptosis, or falling, of the womb. The displacement may also be sidewise, in which case there is a distention of the sustaining and protecting membrane on one side with extreme attenuation of the blood vessels which lie in it, and on the opposite side the blood vessels are obstructed by buckling and kinking. Menstrual irregularities are largely due to the disarrangement of these very important blood vessels. Pains, nervousness, general fatigue, and many serious complications are, according to the highest gynecological authority, mainly due to intestinal pressures which displace the uterus. By preserving the forward tilt of the pelvis and the normal curve of the lumbar vertebræ, this pressure is obviated. Dr. Eliza Mosher, one of the best-known authorities on this subject, found a complete correspondence between this kind of disorder and habitual bad posture.[1] In every case of

[1] Eliza Mosher, M. D., "Habit Postures in Relation to Pelvic Conditions," *Medical Record*, April, 1917; also, "Posture a Cause of Deformity and Displacement of the Uterus," *New York Journal of Gynecology*, November, 1893.

female pelvic disorder of this sort there was habitual backward tilting of the pelvis and loss of the lumbar curve, and in no case was there uteral displacement where this posture fault was not present. As a result of these significant findings Dr. Mosher has for many years and in many important writings been a tireless advocate of posture-training and hygienic school-seating.

Other perils of posture. In addition to the dangers of displacement (enteroptosis, or *visceral prolapsus*), described above, there must be further charged against the stooped posture the direct interference with the functioning of the larger organs by actual pressure upon them. Dr. Herz, a German specialist, states[1] that a large proportion of heart trouble arises from the pressure and strain upon the heart caused by the contraction of the chest walls in habitual leaning or stooping forward and particularly by the laterally uneven pressures resulting from the continued raising of one arm as in writing. He particularly ascribes "Wanderherz" and the beginnings of arteriosclerosis to this cause.

There can be no doubt but that an habitually depressed thorax makes impossible a habit of deep breathing, retards oxygenation and the elimination of toxins, and permanently reduces the "vital capacity" — a term used by hygienists to indicate lung capacity and regarded as one of the most significant of physical measurements. Perhaps the most serious danger in this connection is in the fact that the stooped posture prevents aëration of the entire lungs, and the unused tips thus easily fall a prey to tuberculosis bacilli. This is one of the common causes of pulmonary tuberculosis and a chief reason for medical insistence upon habits of deep breathing.

[1] Dr. Max Herz, "Ueber die Beeinträchtigung des Herzens durch schlechte Körperhaltung," *Therapie der Gegenwart*, June, 1908.

This is an era of great interest in ventilation and fresh air; in open windows, open-air schoolrooms and sleeping-rooms, ventilating systems, and outdoor life. But it should be borne in mind that one breathes only the air that gets into the lungs, not that which gets into the room, and this is a problem of chest expansion and erect posture. Without good posture habits the best ventilation is largely in vain.

It is equally obvious that the downward and inward pressure upon the abdomen interferes with the peristaltic movements of the stomach, which are essential to digestion, as well as with the forward progression of the digesting foods in their long and tortuous course through the intestines. The twenty-foot intestinal channel abounds in kinks and sharp turns, almost any of which may become practically impassable as the result of compression from without. Not only are many stomach and intestinal disorders directly caused by this interfering pressure, but the retardation and interference with their vigorous normal functioning reduces their natural resistance to the contagious and other harmful organisms which, despite all sanitary precautions, are constantly present in the system.

In various degrees the cramped and compressed conditions of thorax and abdomen, with the dislocation of vital organs incident to stooped posture, interfere with the free functioning of nerves and blood vessels. The work load of the heart is tremendously increased by the unnatural bending and pressure upon arteries and veins. It is well known that the sharp bending of the neck in stooping over a desk while one is writing or reading causes congestion of the blood in the eyes and face. Similarly, the compression caused by the inward folding of the abdo-

men at the stomach level in stooped posture restricts the splanchnic circulation which reaches the major vital organs. Furthermore, the autonomic nerve centers controlling the whole functioning and coördination of the vital organs lie just where this bending of the trunk and inward pressure of the sternum causes a direct pressure upon them. These centers are the *cardiac plexus* and the *solar plexus*. The effect of a blow over these great ganglia is so well known that no detailed discussion is necessary to indicate that the heavy pressure upon them involved in stooped posture must have important effects on vital processes even though no sudden shock occurs.

Posture as a problem in vital economics. It is perhaps unfortunate in human physical economy that we are so constituted as to be relatively insensitive to these internal pressures, displacements, and injuries. The comparatively harmless fatigue of the back muscles is very quickly and very keenly felt, and relief is promptly sought by relaxation which, under the conditions of our highly artificial modern sedentary life, commonly takes the form of stooped sitting rather than the perfectly wholesome and more effective relief of lying down. In countless ways the complexities of civilized life have introduced dangers to life and health which would destroy the race if it were not for the progressive corresponding development of highly artificial protective devices. But there has been only occasional complacent recognition of the dangers of the increasingly prevalent sedentary posture or, at most, sporadic agitation with fragmentary scientific contributions. The subject as a whole has not had adequate systematic attention.

The reason for this neglect lies largely in the extremely subtle and gradual nature of the effects of bad posture

and in the fact that both causes and effects are inseparably entangled and hidden among countless other hygienic problems. While an alarmist attitude is expressly to be deprecated, a thorough search for and plain statement of all contributing factors and reasonably probable effects must be of great importance to human welfare. It is not to be supposed that all the ills to which attention is directed in these chapters are the direct or inevitable consequences of bad posture; nevertheless there are a host of specific disorders and an enormous sum total of reduced vitality and efficiency which medical science is struggling to combat, to which habitual stoop is a contributing, perhaps a determining factor, but a factor so insidious that it is not considered in diagnosis or remedial treatment.

It is a matter of regret that we have as yet no statistical data showing the amount of correlation between habitual stoop and ill health of various forms. Common observation and popular opinion would indicate, however, that the correlation is extremely high. Erect posture and carriage are almost inseparably associated with vigor, vitality, and energy, whereas a characteristic stoop is almost inevitably a concomitant if not a symptom of pulmonary tuberculosis, chronic stomach or intestinal disorders, anæmia, and the like. While it may be that the disease is often the cause of the stoop, rather than vice versa, in any case the latter must be a contributing and aggravating condition. Habitual erect posture, with full thoracic and abdominal expansion, normal support of the vital organs, and abundant space for their vigorous functioning, is at the least a favorable condition for the prevention of, resistance to, and cure of most internal disorders.

The influence of ill-adapted seating. The relation of this whole matter to seating lies in the fact that improperly formed or proportioned seats and those which are incorrectly sized to meet the requirements of their occupants make habitually erect posture almost impossible. A seat so formed that one cannot relax against the back support without sliding down into an unhygienic stoop is a positive factor in making that stoop habitual. Because of their hard and smooth surfaces and because of the long hours through which they are occupied by children in the most susceptible period of life, school seats are particularly dangerous as contributing factors to chronic ill health. The fundamental requirement of a school seat that will avoid this positive danger will be found in a construction which will favor the erect position of the pelvis and preservation of the lumbar curvature.

CHAPTER V

SCHOOL POSTURES AND SPINAL DEFECTS

The borders of orthopedics. The preceding chapters have dealt only with that postural condition which is characterized as stoop. It is not within our province to enter into a technical discussion of those distinctly pathological conditions classified as spinal defects. For an adequate treatment of the nature, causes, progress, and correction of these defects the reader must turn to the abundant medical literature of orthopedics. Nevertheless habitual posture enters so largely into the causation of spinal defects and the muscular and organic complications inevitably involved with them, and these spinal troubles so frequently complicate the problems of posture, that a brief, untechnical presentation of these defects is necessary to any adequate treatment of our topic.

Origins of spinal defects. With spinal defects due to congenital causes or to tuberculosis or other infectious diseases of the spine, we are not here concerned other than to say that they are enormously complicated by the strain of maintaining any sitting position, particularly without suitable support. Aside from these cases, the more serious spinal defects are in general due to improper nutrition combined with postural difficulties. Rickets, a very common disease of children, is due to an inadequate supply of bone-building elements in their diet, resulting in soft and undeveloped bones, which are

readily susceptible to malformation from any strain of continuous or oft-repeated pressure. Owing to the fact that these rachitic children are muscularly weak it is peculiarly difficult for them to sit or stand erect, and asymmetrical posture habits are almost certain to be formed; they become bow-legged or knock-kneed; cranial, pelvic, or long bones may be variously misshapen, and the spine almost inevitably twists or buckles under the strain of sitting up. While only extreme cases are definitely diagnosed as rickets, relatively few children are perfectly nourished, and even the most fortunate enter upon the strain of sitting, standing, and walking with bones yet quite soft and cartilaginous. Many serious and innumerable minor deformities occur as a result of unwise stimulation of infants to assume these upright attitudes more rapidly than the ossification of their skeletal framework justifies. Much sitting during the earliest school years is peculiarly dangerous; and unhappily the most susceptible children are the frail, anæmic, and rachitic ones who, being least disposed to vigorous running games, are most commonly found sitting bent over their books.

Types of spinal curvature. Since spinal defects manifest themselves as abnormalities of curvature they are ordinarily classified according to this characteristic as follows: (1) scoliosis, under which are included all twists and sidewise variations of the spine from the median vertical plane (Fig. 7); (2) kyphosis, including any forward stooping defect such as round shoulders, flattening of the lumbar concavity, forward extension of the neck, humpback or less pronounced exaggeration of the thoracic convexity (Fig. 8); (3) lordosis, which is an exaggeration of the lumbar concavity with forward

protrusion of the pelvis. While these terms are ordinarily used in medical literature to refer to pathologic conditions involving malformation of bony structure and cartilaginous connections with more or less serious degeneracy of muscular tissues, they are also applied to habitual postural tendencies and are even used adjectively to refer to position without pathologic implication; as, a kyphotic or scoliotic posture.

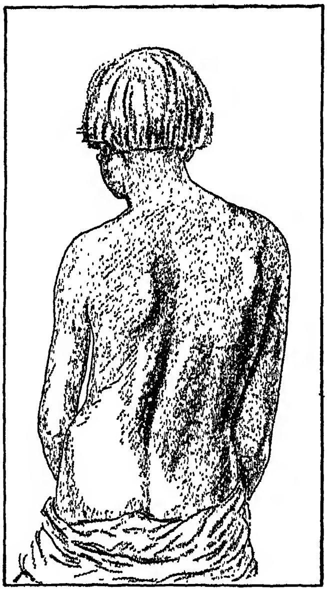


FIG. 7. A typical case of scoliosis

Scoliosis. Of these three defects scoliosis has had by far the greatest attention in the literature of medicine and school hygiene. The effects of scoliosis in the displacement and compression of vital organs are similar to those described in the preceding chapter with reference to habitual stoop. They are, however, more likely to be acute and hence are more often cases for medical attention. The forward stoop is involved in the imperfect development of the erect habit of life, but lateral irregularity is abnormal in either quadrupeds or bipeds. Scoliotic distortion of the thorax involves serious direct pressures on heart and lungs and restricts the mechanical movements of the ribs in breathing. Lateral bending or twisting of the spine also produces pressures on the spinal cord and its branches which

may involve paralysis of either internal or external portions of the anatomy. Pinching and stretching of the vertebral branches of the blood vessels may also be involved.

Prevalence of scoliosis. Medical reports are found showing anywhere from 3 per cent to 86.7 per cent of school children examined affected by some degree of lateral spinal curvature. The variations are due in part to actual differences in conditions prevailing in different communities, but more largely to differences in standards and methods of examination. A considerable proportion of practically normal persons are doubtless slightly imperfect in symmetrical development. Most of these are entirely unaware of their imperfections and are not seriously affected by them in health or efficiency. The degree of curvature which is noticed and recorded depends on the purpose of the inspection and the thoroughness with which it is made. Examinations which have sought for spinal irregularities have found a far larger proportion of them than have the usual physical or medical examinations of children, in which only pronounced cases are noted. Examinations by orthopedic specialists have usually been made with subjects stripped; ordinary school inspections are commonly

FIG. 8. A typical case of kyphosis

made with the children clothed, and the great majority of slight cases and even many serious ones cannot be detected through the clothing.[1]

It is to be noted that the proportion of scoliosis is invariably considerably greater among girls than among boys, and the indications are that the disproportion increases with increasing age toward and probably after maturity.

The number of cases of scoliosis increases from the beginning to the end of the elementary-school period, though some writers believe that it decreases in its serious forms in the higher schools. How far this latter conclusion is due to incomplete data, how far to elimination of the afflicted ones, how far to corrective training, and how far to a tendency to outgrow the defect, is not evident from the literature available. The Lausanne examination reported 8.7 per cent in the first grade, 18.2 per cent in the second, 19.8 per cent in the third, 27.2 per cent in the fourth, 28.3 per cent in the fifth, 36.4 per cent in the sixth, and 31 per cent in the seventh.

A school disease. The close relation between the occurrence of scoliosis and school life has been noted by all writers on the subject, and most studies of the disease have culminated in efforts at reform in school-seating as well as in corrective physical training. Eulenberg reports

[1] Combe and his associates examined 2314 children in Lausanne and found 23 per cent of the boys and 26.7 per cent of the girls affected with scoliosis. Hageman in Moscow found 29 per cent in 1664 cases examined; Kallback in St. Petersburg, 23 per cent of both sexes; Herman Meyer, 62 per cent among 386 girls; Schulthess, 86.7 per cent among 377 girls; Guillaume, 17.71 per cent among boys and 40.94 per cent among girls, of 731 children examined at Neuchatel; Dufestel, 32.85 per cent among 116 primary-school girls in Paris; McKenzie reported 23 per cent in a Canadian boys' high school, 12 per cent among the students of McGill University, and 27 per cent at the Royal Victoria College for Women; and Canavan found 35 per cent among 2333 Wellesley College girls. Redard is reported to have found 200 cases among girls to 37 among boys.

that 88.7 per cent of 1000 cases of scoliosis examined by him developed the curvature between the sixth and fourteenth years. Whitman recorded 201 cases, in 150 of which the curvature was discovered during the first nine years of school life. Of 400 cases under treatment at the Boston Hospital for the Crippled and Ruptured, school life was pronounced a determining cause in 71.25 per cent of them. Kocher calls lateral curvature a school disease. Dr. Lovett states, "The figures show that scoliosis is a constantly increasing affection during school life, and it is a matter of common information that 'school scoliosis' and round shoulders are frequent in school children." Dr. Frederic Cotton in 1904 wrote, ". . . the evils of bad furniture are now fully admitted. It is well established that defective furniture is a potent factor in causing the round shoulders, spinal curvature, and short-sighted eyes that are still so commonly found to be developing in school children." The Commission on School Sanitation of the National Education Association in 1896 included in its report an approval and quotation of Dr. Scudder's conclusions, among which are these: "that the present method of seating tends to the production of permanent deformity of the spine" and "that the poor seating in our schools has not been hitherto sufficiently emphasized by orthopedic surgeons." Dr. E. R. Shaw in his "School Hygiene" (1910) says, "The desks now widely in use are, as a rule, instruments productive of deformities." Cornell writes, in his "Health and Medical Inspection of School Children," "Most cases of lateral curvature are primary in causation and due to faults in our school system." Dr. F. B. Dresslar in Monroe's "Cyclopedia of Education" says, "School desks as at present made are undoubtedly demanding

abnormal postures and making them habitual"; and in his "School Hygiene" he says: "The most serious defect of the average school desk is that it subjects the pupil to a posture that fosters spinal curvature, cramped chest, and defective vision. . . . Children will bend over their work day after day unless we devise a practicable desk top that will necessitate erect normal posture for all their work." Similar opinions, more or less concisely expressed, are to be found in Dufestel, Mery et Génévrier, Eulenberg-Bach, Burgerstein, Burgerstein and Netolitzky, Baginsky, Schulthess, Kotelmann, Cohn, Terman, Gould, and practically all writers on school hygiene and related questions.

Predisposition. The more conservative writers point out that the schools produce spinal curvature only in those children who for various reasons are predisposed to it. The following quotation translated from Dufestel is pertinent:

We are concerned here only with scoliosis of pupils; that is, (school) scoliosis proper, leaving aside all those forms which result from other causes. It is necessary to distinguish that scoliosis of bad posture which very commonly disappears when the child resumes his normal position. Scoliosis proper, on the contrary, is characterized by a permanent malformation of the spine, reducible with difficulty by a twisting of the vertebral body and by a costal projection. The more frequent is the dorsal scoliosis to the right.

Predisposing causes are numerous. We may indicate, without insisting upon them, rickets, heredity, constitutional troubles at the time of puberty, relaxing of the tissues, muscular feebleness, and especially anæmia.

Bad postures, particularly sitting postures, are veritable effective causes among those predisposed. The child seated on a seat badly proportioned to his size, at first avoids bad posture by changing his position, by constant movement to the despair of his teacher, and in seeking a position of relaxation; but little by little, the scoliosis, at first temporary, becomes fixed. There are especially vicious attitudes taken in sitting position which among the predisposed rapidly develop scoliosis.

The act of sewing, of drawing, of writing on a desk poorly adjusted to the size of the pupil, suffice to give a defective position which by habituation degenerates into a grave deformity of the spine.

It may be that strong and healthy children whose physical training and out-of-school exercise are adequate and vigorous suffer only annoyance and discomfort from the ill adjustment and adaptation of school-seating to their needs. Nevertheless there is good reason to believe that even among these favored ones posture habits are formed which later sedentary life may convert into positive physical defects. At best there is a large and unknown proportion of pupils who are more or less enfeebled by various degrees of malnutrition, by anæmia, by rickets, and the like, and these predisposed children are unquestionably affected by bad seating conditions to the extent that permanent deformities commonly result.

FIG. 9. Typical reading posture with flat-top desk

Elements of the school's responsibility. The consensus of opinion as to the responsibility of school life and particularly of school furniture makes imperative an analysis of the specific factors tending to scoliosis. First is to be noted the bare fact of the long hours of sitting at a desk, with a minimum of corrective movement or exercise and with unyielding seats and backs which, instead of

comfortably conforming to the shape and movements of the body, force the soft flesh and yielding forms to conform to their own rigid lines. The continuous strain of supporting the weight of the upper body is in itself sufficient to produce a yielding of the flexible spine at some point, particularly if there be a point of undue weakness. The remedy for this lies primarily in the improvement of the schedule, providing for shorter periods, alternation of desk work with occupations requiring exercise and change of posture, and perhaps also in the use of upholstered seating equipment.

FIG. 10. Typical posture in writing on high, flat surface. Note right curve of spine at lumbar level, sharp bend and twist at level of shoulders and neck, uneven height of shoulders, and bad visual angle and distance. Both arms on table

Pelvic tilt. Secondly, any condition which tilts the pelvis laterally contributes directly to producing scoliosis. This may be due to sitting with one side to the desk on a seat which is elevated near the front edge, using a seat with a sagged or deep-scooped surface, habitual crossing of the legs above the knees, sitting on the foot, extending the feet into the aisle or bracing them against a support not centrally placed. Such practices may be harmless if

frequently reversed; but, to the extent that they become habitual, there appears to be a tendency to fix the habit in one direction rather than in both. Similar tendencies result from the habit of standing with the weight on one foot, with one foot extended or one knee bent, from the "débutante slouch," and the like.

Asymmetrical elevation of shoulders. Thirdly is to be noted any position which continuously elevates one shoulder more than the other. Writing on desks too high (Figs. 10 and 11) has properly been regarded as one of the most prolific causes of scoliosis. Although this danger has been somewhat lessened by the present method of requiring children to write with both arms resting symmetrically on the desk, there is still a tendency to tilt the head to the left with compensating thoracic bend to right. Particularly harmful is the use of desks with arm rests extending back under the writing arm (Fig. 12), or of tablet-arm chairs on which the arm is higher than the elbow when drawn well back and down. It is seriously harmful that such arm rest should elevate the writing elbow while the writing is being done, but far more so

FIG. 11. Writing on high, flat surface. Same as Fig. 10, but with left arm hanging down

that it continues to keep that elbow raised while the pupil is reading, reciting, or otherwise engaged. While writing, the necessity for free movement of the arm prevents one from leaning heavily upon the rest; but much of the time when he is not writing the pupil practically hangs his weight from the shoulder. A study of the use of such arm rests discloses two other postural habits both tending to scoliosis: one is writing with the left elbow on the desk while the right is drawn far back (Fig. 13), producing a right twist of the spine and sharp compression of the right thorax; another is reading or reciting while using the corner formed by the back and the arm rest as a back rest (Fig. 35), thus adding a left twist to the exaggerated elevation of the right shoulder and pressure of the ribs on the heart. Single arm rests should be used only on tablet-arm chairs, and then should be so low as to offer no temptation to hang on them by the elbow.

FIG. 12. Spinal curves resulting from elevation of right shoulder by means of an extended arm rest at the height of the desk. Left arm hanging naturally

Turns and twists. Finally, any condition that encourages children to sit sidewise or twisted in the seat is to be avoided. This is often done to get a better light on the work, to relieve astigmatic defects of vision, to avoid the glare of uneven illumination on a glazed-paper surface, or to see better the point of the pen when obscured by the hand in writing position, or by working with pelvis and shoulders facing in different planes. This twisting may be due to seeking a foot rest in the desk irons, to habitual sprawling, or to a seat so placed at a front corner of the room as to require prolonged turning toward the same side in order to face the teacher or the blackboard. Occasional turning of the sort is, of course, not to be regarded seriously, but the routine of school life is such that a tendency which affects posture at all is likely to recur with frequency and become habitual.

FIG. 13. Spinal curves and torsions resulting from elevation of right shoulder by means of an extended arm rest at the height of the desk. Left arm extended on the desk for support

Kyphosis and stoop. Kyphosis in its milder forms, as stoop or round shoulders, has been considered at length in the preceding chapters. There is no definite standard of erectness, such as the straight line affords with reference to lateral curvature, and it is probable that a considerable range of variation in the anterio-posterior curvature may be entirely normal. Varying conditions of fleshiness and fatty tissues render quite impracticable any judgments based on superficial lines. The writer has, by means of a flexible-curve rule, made drawings of the back profile of several hundred pupils of various ages. Not only does there appear to be no standard of gross curvature which can be designated as normal to the exclusion of wide variations in either direction, but the position of the crest of the lumbar concavity fluctuates surprisingly from the sacrum almost to the shoulder blades. Furthermore, these curves vary considerably in the sitting

FIG. 14. Straight position of spine in the modern method of writing with both arms placed symmetrically on the desk. The pupil, desk, and seat in this figure are in all respects identical with those shown in Figs. 12 and 13, except that the extended arm rest has been removed

position from their form in standing, and vary differently in different individuals. Many who stand easily with pronounced lumbar curve, habitually sit with a decided stoop and are apparently unable to sit erect without lumbar support. For such reasons as these we have no statistical data as to the prevalence of stoop. Its pathological effects are so insidious and subtle, so likely to be diagnosed as cardiac, pleural, intestinal, pelvic, or other disorders, without mention of postural causation, that medical records throw no light on their frequency. Only diseased conditions of the spine itself resulting in pronounced deformity are likely to be classed in medical records as kyphosis. If, however, ordinary observation is to be trusted, and if all variations from the distinctly erect are to be regarded as defective, certainly the prevalence of stoop and its evils is enormous. Thoroughly good erect posture is the exception, and some degree of spinal sag is the rule. While all cases of the latter are not to be regarded as pathological, erectness so definitely expresses vigor and energy that it may be regarded as a standard of physical perfection from which all variants are deficiencies if not defects. Considered in this light, the total loss of human vitality, happiness, and efficiency due to habitual stoop is perhaps far greater than that due to scoliotic defects. As a problem of human welfare it is perhaps the more serious. Comparisons, however, are of little import. The two defects are commonly complicated with each other, and either is serious enough to deserve the fullest consideration that can be given it.

Causes. The factors contributing to stoop are most of those involved in the proportions and form of desks and of seats, either in or out of school. Desk-work too low and too near the body, or too high, flat, and distant to

permit a restful, poised position, or requiring a forward and outward spreading of the elbows with resulting flattening of the chest, are all productive of stoop. Back support at the shoulders or at the pelvis involves a sagging at the lumbar curve as the back muscles relax, as does any continuous back support rising from the seat and making contact at the buttocks, any elevation at the rear of the seat-bed, or a seat too deep, or any working conditions encouraging a tendency to slide down in the seat, as well as any uncomfortable edges, ridges, or limited areas of pressure which make erect position uncomfortable and sagging a relief. In short, nearly all the problems of seat and desk construction from the hygienic point of view are problems of avoiding stoop and of making erect sitting comfortable.

Lordosis. Lordosis seems hardly to be a sitting defect. It takes the form of a forward-protruding pelvis and abdomen with flattened chest. It is due to a weak condition of the muscles which causes one to stand in this posture, but may result in ordinary stoop when one sits. It is probably not directly attributable to defects in seating equipment except as these contribute to general muscular debility. It is probably contributed to by the too early and persistent sitting up of rachitic and other children predisposed to spinal weakness.

CHAPTER VI

BEAUTY AND THE BEAST IN POSTURE

The structure of a biped. If the genus homo has changed from a horizontal quadruped to a vertical biped, that transition has involved numerous structural changes of fascinating interest in the study of posture. The spine has changed from a trusswork bridge to a true supporting column; the head, from a swinging prehensile instrument to a poised part primarily devoted to the activities of the higher senses; the fore limbs and their supporting girdle, from their position and character as organs of locomotion to free-moving, suspended instruments of manipulation; and the pelvis has developed from a group of loose articulations of the rear limbs with the spine into a rigid framework ideally adapted for carrying the entire upper weight poised on the head of the sacrum, for its supporting and protective functions with reference to the vertically rearranged viscera, and for its central function in sitting, standing, walking, and the enormous range of bodily activities which man has acquired the ability to perform.

Attention has frequently been directed by scientists to minor changes with which we are not here directly concerned, such as the cranial development and the retrocession of eyes and jaws, the mobility of the hand and the opposition of thumb to palm, the almost universal range and direction of arm movements, and the lengthening of the foot base with the poising of the weight on a

resilient arch. Innumerable other changes of equal interest have to do not so much with the vertical carriage as with changed habits of sheltering, clothing, feeding, communication, thought, and the arts of civilized life.

In the preceding chapters we have touched upon the development in the human biped of the normal curves of the spine and the corresponding changes of musculature and devices for supporting and protecting the vital organs to prevent their piling down upon each other by the force of gravity and the rupturing of their enveloping tissues. The heart and circulatory system, the digestive apparatus, and the nervous organization have likewise gone through marked changes to fit them for functioning in the vertical position.

Stoop a transition phase. Dr. F. H. Martin in an interesting study[1] has shown that the partly erect carriage is essentially weak and ineffective; that apes in the transition stage from quadruped to biped habit have sacrificed much of the sure swiftness and mobility of the former and have not yet attained the marvelous adaptability of the latter. They are in an ill-adjusted, awkward stage: badly poised and lacking in mechanical efficiency commensurate with their muscular power. Dr. Martin applies his comparison to human posture with special reference to visceral prolapsus and shows that the round-back, stooped posture is fundamentally weak, inadequate, and unhealthful.

Erectness a perfection. Miss Jessie H. Bancroft, whose work as president of the American Posture League entitles her to profound public gratitude, maintains[2] that

[1] F. H. Martin, "Visceral Prolapsus," *Surgery, Gynecology, and Obstetrics*, December, 1908.

[2] Jessie H. Bancroft, "Some Educational Aspects of Physical Training," *American Physical Education Review*, Vol. XV, p. 233.

good posture is to be consciously cultivated and developed as a dėfinite step in the progress of the race, and that bad posture is not a mere deviation from the normal but a problem in the latest step in man's evolution. Following this lead one is impressed that the study and cultivation of right posture is removed from the realm of mere chance survival of the fittest and assumes its place, like the study of medicine, of sanitation, of economics, of ethics and government, of agriculture, and other applications of pure science to human progress, among the agencies through which man is utilizing his intelligence for the improvement and perfection of his race.

The psychology of posture. The highest human traits and the finest moral perfections are inseparably associated in our thinking with erectness of carriage and posture. Our very language testifies that our concepts of moral qualities are derived from physical bearing: witness such terms as "uprightness," "poise," "well-balanced," "level-headed," "backbone," "chesty," and a host of others. We inevitably judge character from postural evidences. We ascribe poise, dignity, confidence, courage, self-reliance, self-respect, leadership, aggressiveness, and dependability to those whose posture expresses such traits. Military bearing — the presumed embodiment of courage — is essentially erect. Stooped, slumping, slouchy, round-backed, and narrow-chested posture suggests ill health, weakness, inadequacy, discouragement, and defeat. One set of traits are ascribed to those who have a firm, well-balanced, energetic tread, and a very different set to those of a shifty, shuffling, shambling gait. One cannot think of an energetic, commanding presence as associated with a drooping,

hollow-chested posture. Even temporary emotions and attitudes are expressed through physical posture. We know what has happened when in the midst of a moral struggle one lifts his head and squares his shoulders. We recognize the posture which tells of defeat, discouragement, and shame.

The psychology of posture has been so taken for granted that its systematic formal study has been neglected. Yet whether viewed with reference to its social influence, its expression of psychical states, or its reflex effects in producing such states, few factors of human conduct can be more significant. Both social psychology and practical education would be profited by an analysis of this factor. Diagnostic tests of mental and moral traits might well include elements based on analysis and correlation of such qualities with characteristic physical attitudes and bearing.

Cause or effect? Where such close correspondence obtains between traits and their physical manifestation an important educational question arises as to the causal relations between them. Is it to be supposed that character is established wholly by other agencies and that posture is a merely incidental expression? Or is it possible that posture may be determined in large measure by physical training and the mechanical effects of seating equipment, with important reflex influence on character development? Certainly military training and its adaptations to Boy Scout and gymnastic purposes has proceeded with success upon something like the latter assumption.

Moral and physical backbone. No one would suggest that character can be formed by a strait-jacket or intelligence derived from a hygienic seat back. Nevertheless

it is probably true that very much of the best teaching is futile because physical conditions and equipment render habitual good posture disagreeable, fatiguing, or impossible. It is doubtless true that some individuals are incapable of the highest human qualities. Is it not true also that they are incapable of the corresponding excellences of posture? Individuals of superior native ability doubtless have a way of overcoming all obstacles to the development of mental and moral power. They likewise overcome the most detrimental influences in acquiring the sort of posture which expresses their character and achievements. They may even gain in moral worth and physical comeliness by virtue of overcoming moral temptations as well as the physical temptations of atrociously unhygienic seats. But mental, moral, and physical education alike have abandoned the theory that the best development is attained through making the way as difficult as possible. Ill-proportioned and uncomfortable seats never contributed to the making of straight backs and broad chests, any more than an illiterate environment contributed to precision in English, or association with vice to moral purity and high ideals. There are difficulties enough in the way of developing either moral or physical backbone to exercise the spirit of conquest, and the removal of the cruder temptations to moral or physical slump but clears the way for higher attainment and finer standards of achievement.

Even as you and I. The great mass of human beings, however, are neither subnormal nor supernormal, neither hopeless nor invincible. They are improvable and desperately in need of improvement. They are susceptible to every environmental influence to which they are subjected, and the end product of their education is little

else than the sum total of the educational efforts expended upon them. This is the great group that includes the most of us; this is the philosophy of universal education; this is the only theory by which nations, races, and generations of humanity are elevated to higher levels. The 2 or 3 per cent will never remain erect no matter what is done for them, as many more will grow erect despite whatever is done to them, but the rest will grow straight or stooped, erect or slouched, soldierly or scoliotic, largely according to the physical conditions and influences under which they develop.

Sit up and pay attention. Psychology of posture must take into consideration that even though a physical attitude may not be the cause of a desired mental state it may, nevertheless, be a requisite thereto. Teachers long ago learned to infer inattention from a physical slump, whatever may have caused the slump, and to regard the two commands "Sit up, and pay attention" as practically inseparable. Educational science must consider that whatever makes sitting up easier makes the paying of attention more sure, and that habitual sitting up contributes to, if it is not actually essential to, habitual paying attention. If a particular seating equipment encourages erect posture and thereby contributes but a small percentage of increase to the learning efficiency of pupils, the increased returns from investment in years of teachers' salaries and overhead costs would amount to many times the cost of the equipment.

The alert poise. In connection with the psychological alertness which is characteristic of erect posture, there should be considered the practical efficiency of this poised and well-balanced position. The countless slight movements involved in all sedentary work may be made

with the least expenditure of time or energy and without change of position other than that involved in the specific activity. In any other position — reclining, slumped, stooped, or leaning on a desk — a definite lifting of the body weight is necessary to almost any change of activity. What being "on his toes" means to one about to run, erect sitting means to one engaged in sedentary work. It is an alert readiness to respond to any stimulus to movement, and yet is entirely without fatiguing strain or tenseness. Unquestionably many a minor detail is neglected or carelessly done through sheer inertia incident to slouching in one's seat or leaning on the desk. Doubtless these trifling neglects tend to more or less slipshod habits of work, and if they become the characteristic of the infinite details of long years of school work — the years of habit and character formation — the cumulative psychological and social effect may be of large educational importance.

No statistical social or psychological studies are required to demonstrate the moral effect of erect posture of the pupils upon a teacher or class at work. Nothing can be more stimulating or indicative of attention ~~and~~ esprit de corps than a class all sitting erect at work; nothing more surely indicates low-grade class work than a group slumped and sprawled and stooped in countless graceless positions. Few things are more irritating to a teacher than the sprawling boy. When one does feel the urge to throw off lassitude and to attack a task energetically, he begins by "pulling himself together" into an erect posture. It would seem superfluous to insist further that whatever would tend to make erect posture less difficult in the classroom would be a material contribution to disciplinary and learning efficiency.

Posture and beauty. Erect posture is too little appreciated as an index of human wholesomeness, of physical attractiveness, of fitness for parenthood, as one of nature's dominating influences in sexual selection. Men, of course, are physically attractive largely in proportion to their vigor, self-reliance, energy, and courage, which may be summed up as virility and which is evidenced by their manner of sitting, standing, and walking. But women have been so buffeted about by the dictates of fashion and the changing tides of social custom that they have often neglected nature's supreme gift of attraction in the multiplicity of artificial feminine wiles. The essentials of beauty in woman have always been the same and are as evident in Greek art as in the modern girl. But the ambitions of women have been determined by the reigning belle of the day or the mercenary dressmakers of Paris. Transient ideals of beauty have flitted through the centuries from absurdity to absurdity, as evidenced by fashion plates from the time of Tutankhamon to the latest fashion magazine. Charm is not in the "dêbutante slouch," the flapper's flop, the paleness and face patch of the eighteenth-century belle, the bustle behind nor the "straight front," the uncanny hues of lipstick and rouge, but in physical development and resilient energy. When girls seek deep-chested, poised erectness and the prizes of nature's sweet tinting as the supreme form of attractiveness, what a generation of mothers will arise!

Woman's rights and wrongs. Scoliosis, stoop, pelvic disorders, and other physical penalties which must be paid for habitual bad posture are far more frequent among women than among men. Owing to sex differences in occupation, in nervous organization, and in vital func-

tions, these disorders are also far more serious and entail incomparably more suffering among women than among men. In the primary grades the average posture among little girls is more erect than is that among boys; in the higher grades sagging posture is far more prevalent among girls than among boys (see Chapter VIII). The period of school life is thus the period of increasingly bad posture habits. It is at the same time the period of increasing prevalence and increasing seriousness of the disorders which grow out of bad posture, and it is the females of the race who are bearing the overwhelmingly large proportion of this burden of suffering — a burden which is not laid aside with their books on the day of graduation but which all through life doubles their load of labor, divides the joys of recreation, deprives them of freedom and privileges, accelerates the dread approach of old age, and multiplies the perils of motherhood.

Not only "scoliosis is a school disease," but all postural disorders are schoolgirl diseases. To make the disparity worse, the occupations, relaxations, contacts, and challenges of a man's life correct such postural ills as he may have acquired at school far more than is true of women. These ills are remediable for the most part and even after maturity can be overcome if one will pay the price of long-continued corrective exercise and posture. But sewing, scrubbing, cooking, and dish-washing, the sedentary work of stenographers and routine of office clerks, the monotonous grind of factory operatives, or the long standing-hours of a saleswoman, are not of a corrective sort. They tend rather to increase and complicate the spinal fatigue and defects. Women have too little opportunity during working hours and too little residual strength and courage during hours

of rest and recreation to keep the back erect and shoulders squared, with thorax and abdomen expanded. To make it worse, the vicious proportions of nearly all chairs render futile such feeble efforts at erect sitting as may be attempted. It will be shown in another chapter that school seats and desks have been almost invariably selected with reference to the minority of husky, well-developed boys rather than for the majority, composed of girls and the frail boys. This is true to even greater degree in the designing of dining-chairs, seats for public buildings and conveyances, and even seats for lounging and relaxation. Everywhere in seating, consideration for their requirements seems to have been in inverse proportion to their need.

Those who would strive for the recognition of woman's rights would do well to focus attention upon hygienic seating from the school desk in the primary room to grandmother's sewing-chair. It is no hyperbole to say that this is a problem of national and racial importance. A generation of vigorous, erect, and healthy mothers, with elimination of the nervousness, petulance, and irritability incident to postural defects and with accession of the cheerful poise and joy of living incident to more vigorous vital functioning, would mean more to the progress of the race than any of the much-bruited political or industrial reforms. We should not fail in appreciation of the gratifying progress that is being made in the physical training of girls and the increasing prevalence of outdoor sports for women, but unhappily these commonly appeal to and reach the least needy few rather than the suffering many. An admirable start too has been made in providing hygienic-posture seating for workers in certain of the industries, a movement worthy

of the highest commendation and widest extension. As yet, however, corrective seating is imperfect even for the fortunate few and wholly lacking for the overwhelming majority of women in homes, offices, and factories.

The universal occupation of girlhood is "going to school"; and here, despite the insistent reiteration of school hygienists, despite the fact that posture habits established in this formative period almost inevitably affect the whole future physical life, figures prove posture to be extremely bad.

Summary. This chapter has sought to emphasize the importance of good sitting posture as an ideal of human perfection, as a contributing factor in the attainment of moral excellence and mental efficiency as well as personal beauty and attractiveness. Attention is called to the peculiar importance of posture in the life and health of girls and women.

CHAPTER VII

POSTURE AND VISUAL HYGIENE

Myopia and the school. "We cannot be blind to the fact that almost all children come to the lowest class of our schools with perfectly sound eyesight, while from class to class there is an increase in the number and in the degree of cases of short sight," wrote Dr. Herman Cohn in "The Hygiene of the Eye in Schools," in 1886, and since that time probably no aspect of school hygiene has received more attention than has that of vision. Eye tests are part of every medical inspection, and a considerable percentage of pupils are recommended for treatment or the fitting of glasses by experts. It is generally known that a large number of children have been retarded, discouraged, and eliminated from school because of visual troubles which manifest themselves as dullness, lack of interest, headaches, restlessness, and intense dislike of any sustained application involving reading or writing. The progressively increasing use of glasses in the higher grades and colleges indicates that the findings of Dr. Cohn are still true in substance.

Dr. Cohn supported his assertion by tabulations of some one hundred and sixty investigations made up to that time, showing that in the schools investigated anywhere from 1 to 80 per cent of the children were afflicted with myopia (short sight). The progressive nature of this defect was shown in a startling manner by his own tests. He found in the (German) village primary schools 1.4 per cent of the pupils myopic; in the town elementary

schools, 6.7 per cent; in the grammar schools, 10.3 per cent; in the lower high schools, 19.7 per cent; and in the gymnasia, or collegiate high schools, 26.2 per cent. In the gymnasia the percentage of myopia increased from grade to grade in the six upper classes as follows: 22 per cent, 27 per cent, 36 per cent, 46 per cent, 55 per cent, 58 per cent. "In every school the number of shortsighted children increased from class to class."

Recent investigations are not sufficiently comparable with those recorded by Cohn to indicate in any reliable manner how far these improved conditions have reduced the prevalence of myopia and other school-caused eye defects. The Boston school reports for 1907, when the first general examination of the eyes of school children in that city was made, showed 31.5 per cent with defective vision. By 1916 the percentage had been reduced to 12.9 per cent and by 1921 to 11.1 per cent. This encouraging improvement is probably representative only of the best city school systems.

As a result of the facts disclosed and interest aroused by these investigations school-building codes have very generally adopted the principle of unilateral lighting with a required window area of not less than 20 per cent of the floor area of the classroom, and seats so arranged that light shall come only from the left (or left and rear). Artificial lighting has been greatly improved; better type and paper are used in the printing of texts; home study has been greatly reduced in amount, and with the general use of electricity the conditions of it have been much improved. The elimination of the common towel and other sanitary precautions have effectually prevented the spread of contagious affections of the eyes.

Visual strain in relation to posture and seating. The phase of the matter which has not had due consideration is the intimate relation between eyestrain and the posture and desk forms which the pupils employ. This

subject has many important aspects which we shall endeavor to present in outline under these heads: (1) direction of the light, (2) intensity of the light, (3) choice of color, (4) visual distance, (5) the visual angle, (6) slope of the desk top, (7) slopes for reading and writing. A full appreciation of these problems by the reader must assume a general knowledge of the structure of the eye, the adjustments and movements involved in visual work, and the nature of the defects resulting from eyestrain.

For the general structure of the eyes the reader is referred to any convenient work on physiology (or physiological psychology). The aspects with which we are most directly concerned are the muscular controls governing (1) the movements of the eyeballs, (2) the expansion and contraction of the iris, and (3) the changing convexity of the lens.

In reading (or in following any moving object) the eyes never move forward with an even sweep. They make three to six or more irregular jumps forward along each line and one jump back to the beginning of the next, with any number of additional jumps forward or back if any visual or mental difficulty is encountered in the reading. Added to the task of moving each eye accurately in these innumerable jerks, is that of keeping the two eyes precisely converged upon the same point at all times, the angle of convergence between them changing at every move. The extremely delicate muscles controlling the convexity of each lens must be kept in constant tension and play to insure that the visual images of the words are kept clearly focused on the retinas. Also the muscles controlling the shutter-like irises are constantly adjusting the intensity of the light which enters the eye. Reading is therefore an extremely active muscular process, if we regard the rapidity and precision of movement rather than its volume and extent. The muscles involved are minute and are delicate and complex in arrangement. Their efficiency in precise and tireless movement is amazing, but obviously overstrain must follow if they are forced to work under unfavorable

conditions. They are subject to loss of contractility as a result of strain or habitual stretching just as the larger muscles are.

Myopia (short sight) is one of the most common of the defects resulting from this muscular strain of the eyes. There is an instinctive tendency when one has difficulty in seeing a small object clearly to bring it closer to the eyes. This is normally helpful. School life, however, has imposed upon the child the necessity of discriminating with great accuracy, during many hours of the day, among the monotonously similar yet ever-varying minute characters which constitute the pages of reading matter. The difficulties which he encounters are due to excessive or deficient light stimulation, the direction from which the light comes, the angle at which the book is held, and especially lack of familiarity with the characters or the words which they form or the ideas which they express. Now none of these difficulties are relieved by getting the book closer to the eyes, and yet that is the instinctive adjustment which the child almost invariably makes. This closeness involves a much greater strain of eye movement, since (1) the angle of movement to make the same length of jump on the line is increased, (2) the angle of convergence of the two eyes is much greater, (3) the convexity of the lens is increased, and (4) the eyeball itself is actively compressed to adjust its length to a clearer focus upon the retina.

Whatever may have been the visual difficulty which the child encountered, his adjustment to it almost certainly involves these strains. But this adjustment of the eyes for near vision necessitates a near position of the book in order to be clearly visible, and so the myopic strain is persisted in. Even the feeling of strain resulting from this nearness is to the child merely a difficulty in seeing clearly, and he tends to adjust himself by getting the book still closer. As we shall see presently, postural and seating factors also contribute to the progressive tendency to too close vision. The continued strain on these groups of adjusting muscles of the eyes results in overstraining them and permanently stretching and weakening those which normally balance them. Myopia is the result, and it tends to be self-accelerating rather than self-corrective.

The iris (the colored ring round the pupil, or lens) serves precisely like the circular shutter of a camera to regulate the amount of light which shall enter the eye so as to insure the most effective image upon the retina. The retina (like the film or plate in a camera) is extremely sensitive to variations in intensity of light, and the image is as readily blurred by excessive light as it is dimmed by insufficient. Either condition involves a nervous irritation of the retina and a strain of the muscles controlling the iris in the effort to correct it. The blinding dazzle which results from suddenly entering from a dim to a brightly lighted area and the blinding darkness when the process is reversed are due to the over-stimulation or under-stimulation of the retina, and the gradual correction of vision is due to the relatively slow readjustment of the iris to the changed situation. Eyestrain results from either excessive or deficient illumination, from frequent changes of the brightness of the thing looked at, and especially from antagonistic light. By the last we mean light rays within the range of vision which are stronger than those coming from the object at which one is looking. The iris mechanism is adjusted to the stronger light and hence is definitely out of adjustment for the less bright object which one is trying to see.

Direction of the light. All modern school-building codes prohibit any light from entering the room on the wall which the pupils face. Front light not only renders all objects between the eyes and the light less visible but produces a strain which promptly produces headaches and dullness in people having sensitive eyes. Though it may increase the actual candle-power light at any point in the room, front light positively decreases the effective illumination for all who face it. Therefore no seats should be permitted to face the light under any circumstances.

But this harmful front light is not always in the front wall. Any source of light which is stronger than that reflected from the book one is reading, and which is

within the range of direct vision, has the same effect in greater or less degree. Unilateral left-side lighting with pupils seated in straight lines, generally accepted as standard for schoolroom purposes, by no means provides light "over the left shoulder" for all pupils. Only those in the forward part of the room have their light from this supposedly correct direction. Those in the left rear of the room receive their light diagonally from the front and are continuously subjected to a more or less strong and harmful glare. This will be true of all pupils facing parallel with the window wall and sitting behind a line drawn from the forward edge of the window area diagonally across the room. This glare may be lessened by lowering shades, but it cannot be entirely eliminated without cutting off the light necessary for those in the right-front part of the room. Since light for all pupils in the room must come from the same windows, and the left-side window light is the best that the architect can provide, the solution of the difficulty lies in arranging the seating so that those pupils on the left side of the room will face inward from the windows at a varying angle; the closer they are to the windows the more they should face away from them.

Details and diagram of this plan of seat arrangement ("the quadrant plan") are given in Chapter XVIII with other familiar and proposed plans.

As far as practicable, light should fall upon the book from a source behind the head and be reflected from the page practically along the same line. To avoid a shadow from the head, the light should fall over the shoulders, preferably the left shoulder, since this avoids any shadow from the writing hand (for right-handed persons). Close

to the window the angle from which the light comes is relatively high, and one should sit with back or shoulder toward the light; but farther away the angle is lower, and to avoid shadows of the head and shoulders it is necessary that the light should come from the left side.

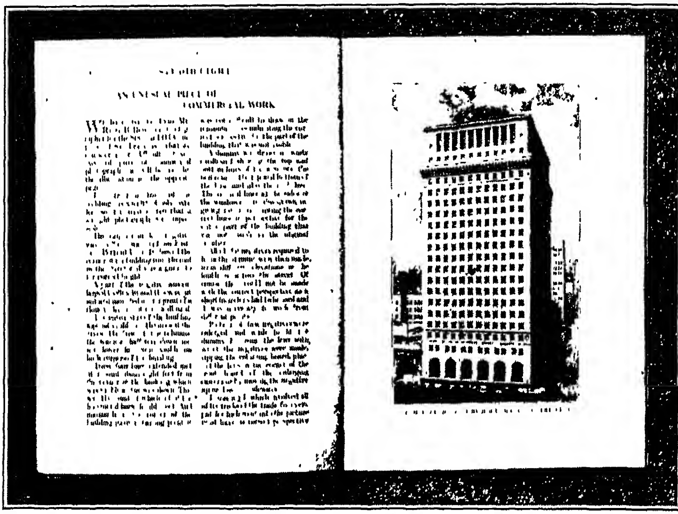


FIG. 15. This photograph was taken with the camera in the position of the eyes and the book at suitable distance and angle. The light came from behind the camera and slightly to the left; that is, "over the left shoulder"

The difference in efficiency of the light coming from different directions is effectively shown in Figs. 15–17. In Fig. 15 the source of the light was from the left and rear of the camera, precisely as though it fell over the left shoulder of the reader, or as it would for a pupil facing forward in the front part of a room having left-side light; in Fig. 16 the light came squarely from the left, as it would for a pupil on the right side of the room; in

Fig. 17 the light came from the left-front direction, as it would for any pupil seated in the left rear of the room and facing forward. The illegibility of this figure indicates part of the handicap which pupils so seated must overcome by bad posture and eyestrain. The intensity

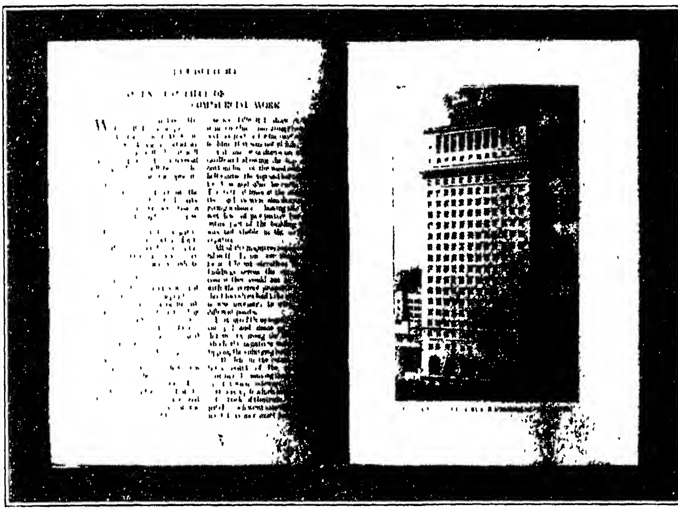


FIG. 16. This photograph was taken precisely as that in Fig. 15 in all respects except that the light was directly from the left instead of from the left rear

and all other factors of the light except direction were kept constant in the taking of these three photographs.

Cross lights, from opposite sides of the room, are invariably bad, both because it is then impossible for the majority of pupils to sit so as to avoid glare from one direction or the other, and because flitting shadows from the writing hand are thrown across the paper, which is irritating to the visual nerves and involves a

constant strain of adjustment of the iris to changing intensities of light on the point at which one is looking. Left-side lighting is as bad for left-handed pupils as right-side lighting would be for right-handed pupils. The difficulty which the 3 or 4 per cent of left-handed

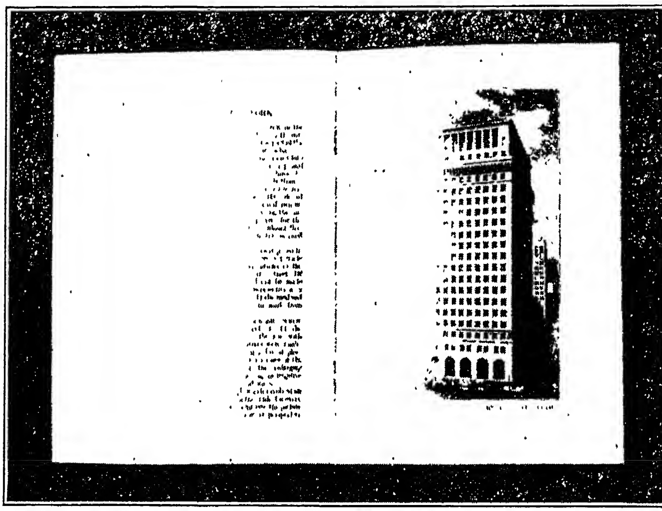


Fig. 17. This photograph was taken precisely as that in Fig. 15 in all respects except that light came from the left front, as it would for pupils in the left-rear part of a room with left-side lighting

pupils must endure in rooms built for the right-handed majority is very much lessened by seating them close to the windows, so that the light falling from a high angle reduces the length of the shadows of the hand to practically zero. Ideal provision for them is made in the "quadrant plan" (Chapter XVIII), in which they are seated at the left front of the room facing inward and have the light over the right shoulder.

intensity of the light. The degree of illumination which is best for school work is a problem for illumination engineers and not within the scope of our subject. Our concern is primarily with insisting that the effective illumination depends upon the degree in which the intensity of the light reflected from the page exceeds that of any other light entering the eyes. Any other light in the background tends to lessen the visibility of the thing at which one is looking. Window light, artificial light, or any highly reflective surface within the range of vision of the pupil as he sits at his work should be absolutely prohibited. Facing pupils squarely or partly toward the light for the sake of any social or grouping arrangement is as indefensible as windows in the front of the room and has precisely the same effect on the pupils so faced. There should be no white, very light-colored, glaring, or glossy walls within range of the pupils' vision. Bright ceilings reflect light upon the pupils' work and not in their eyes and hence are desirable means of increasing illumination, but bright lower walls reflect light into the eyes of pupils and not upon their work and hence decrease illumination. Certain writers on school hygiene have been guilty of the statement that desk tops should be light-colored as a means of increasing the brightness of the room. They brighten the room precisely as a window in the front wall would — by increasing the antagonistic light and decreasing the efficient illumination by which the pupil works. Desk surfaces particularly, and everything in the room that forms a background to the work, should be dark, soft-toned, and nonreflecting. The paper itself should be white and the ink black, so that characters shall be as legible as possible, but neither should be glossy.

Choice of color. It is determined by psychologists that reds and yellows are stimulating to the optic nerve and hence are irritating and fatiguing as a permanent background. Therefore bright-cherry coloring and the yellow "natural wood" tones should be avoided in school and library furniture. Blues are cold and depressing for such purposes unless used in the gay and sunny environment of a kindergarten. All these colors, being dominant and aggressive, are difficult to harmonize with the quiet and soothing schemes of decoration which are appropriate for schoolrooms.

Grays, being in the black-white color series, stimulate the same retinal nerve endings (the rods) as do the black letters and white pages of the book and hence, as background, tend to increase rather than relieve fatigue. Furthermore, their cold, stony suggestion is harsh and depressing. This may not be true of certain "warm" grays found in woven fabrics, which are really mixtures of various complementary colors, nor of "weathered" grays, which are produced by the soft nap of disintegrating and exposed fibers. But these softer grays are not attainable in a hard, smooth, and sanitary varnished surface. Solid black is the most depressing and forbidding of the gray series and is especially objectionable because it is of the same color as the letters which the eyes are required to discriminate.

Soft tones in moss green or walnut brown appear to be unquestionably the best colors for school furniture, from both visual and psychological considerations. They have the additional advantage of being less aggressive than any of the others and easily harmonized with any rational scheme of schoolroom decoration. A certain liveliness and interesting variety in these tones is attained by the varying wood grains.

Further than this the best degree of illumination depends largely on the character of work being done, the size of print, and probably individual variations of visual acuity. The amount of candle power of illumination which is entirely satisfactory varies greatly and

is often multiplied or divided in the course of a day by passing clouds. A swivel seat, which enables the pupil to turn so that light falls squarely over his shoulder upon his book, or a tilting top, which brings the page at right angles to his line of vision, may add more to the effective illumination than raising a shade or turning on an electric light. Pupils in modern American schools suffer far less from lack of illumination, natural or artificial, than from excessive and badly directed light.

Visual distance. The normal distance at which one is supposed to read good print in a fair light is approximately fifteen inches. Actually, individuals vary widely in this respect owing, primarily, to variations in the length of the eyeballs. Young people tend to shortness of vision (myopia) and old people to farsightedness (hypermetropia or presbyopia). Owing to the instinctive tendency to bring the eyes closer to an object which one has difficulty in discriminating, even though the difficulty arises from the light, perspective, lack of familiarity with the word, or other cause unrelated to focal distance, school children constantly tend to get the eyes closer to the work than is favorable to easy focus. Furthermore, the typical pupil's reaction to the discomfort and fatigue of ill-shaped and ill-adjusted desks is almost always such as to bring his eyes very close to the book. For example, if he sits back and holds the book in his hands or the hollow of his arm, bracing his elbows against his body to avoid arm fatigue, the book is usually within ten inches of his eyes. If he lays it upon the desk top, he must get his eyes almost vertically over it in order to avoid the foreshortening of the characters. This causes a back and neck strain, which he relieves by resting his head on his hand, elbow on desk, and this brings his eyes

within six or eight inches of the book. Approximately the same is true if he slides far down in his seat and rests the book against the edge of the desk. He often writes with elbows spread far out on the desk and nose within three or four inches of the paper. All these are illustrations of bad

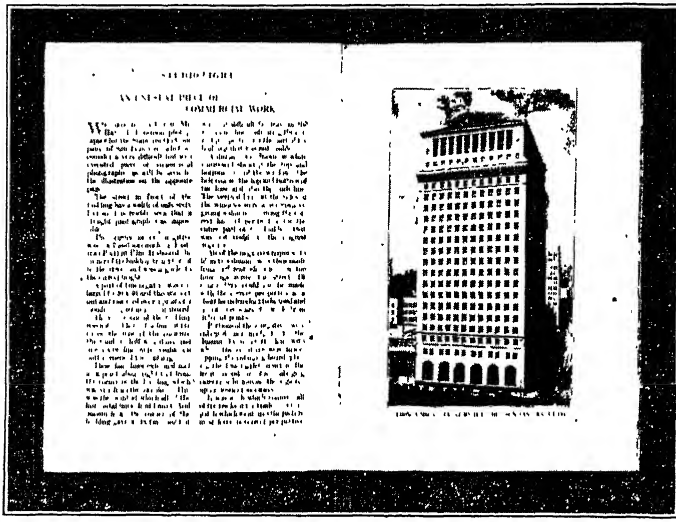


FIG. 18. This photograph was taken with the camera in the position of the eyes, with the book held at correct focal distance and at right angles to the line of vision

posture which tend to become habitual themselves and to cause chronic myopia. Astigmatism and other visual defects, neck and back fatigue resulting from stooped posture, school weariness and drowsiness, all cause pupils to rest their heads on or over the desks. So long as one maintains the erect posture which we have described in previous chapters these tendencies to visual defects, at least, will not occur. The problem is to provide, in connection

with a hygienic seat, a desk surface upon which the pupil can and will do his school-work of various kinds without sacrificing correct posture or proper visual distance.

The visual angle. Figs. 18–20 show clearly one reason why pupils do not sit erect. In these photographs the

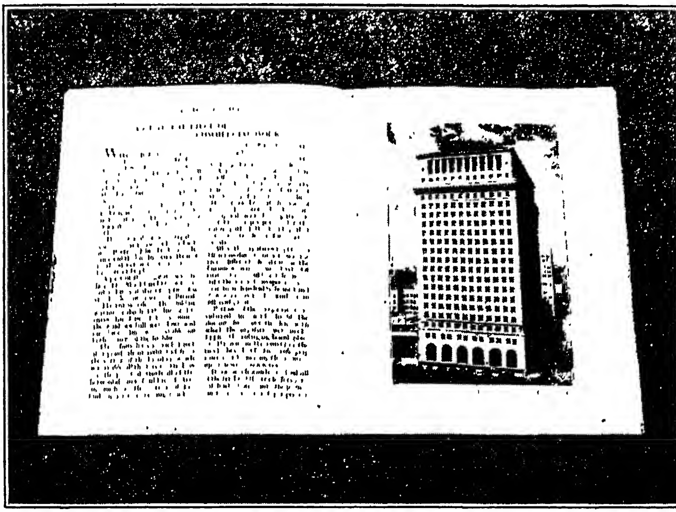


FIG. 19. This photograph was taken with all conditions exactly as in Fig. 18 except that the book was held at an angle corresponding to that of a desk top with considerable slope

camera was placed as the eye of the pupil would be when he is seated erect in his school seat. In Fig. 18 the book is at normal reading distance and at right angles to the line of vision, well up, about the level of the chin; in Fig. 19 the book is at the same distance but lying on a desk top with a considerable slope; in Fig. 20 the book is on a flat-top desk. The difference in the pictures is due wholly to the foreshortening of the book and the

characters printed on it by reason of the angle at which it is held to the line of vision. Only when we attempt to draw it do we realize that a square table top or similar object is a very much distorted rhomboid when seen in perspective. Only from such a photograph as Fig. 20

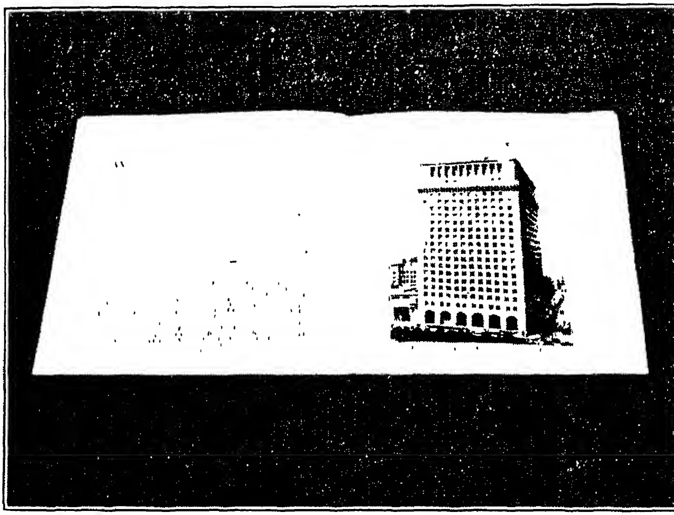


FIG. 20. This photograph was taken with all conditions exactly as in Fig. 18 except that the book was held at an angle corresponding to that of a flat-top desk. Note the foreshortening, the difference in clarity between the top and bottom of the page, and the effect of the antagonistic light reflection at the top of the page

do we appreciate that the same distortion of every letter and word occurs when we see a page in foreshortened perspective. Only when the page is nearly vertical to the line of vision are the words easily legible. Because of this, when the pupil's book or writing lies on the desk top he stoops far over so as to look squarely down upon it. If he stands the book on the desk, he slides down in

the seat to bring his face squarely in front of it; if he holds it in his arms or lap, he cramps his neck and back until he gets a favorable visual angle and distance. Again our practical problem is to provide him with an equipment in which he can sit erect with his reading and writing within a reasonable visual angle and distance.

Slope of the desk top. Obviously a flat desk top necessitates that work done on its surface be done at a bad visual angle unless one leans far enough over it to overcome that difficulty. In that position, looking directly downward, a sharp neck bend is involved which soon becomes fatiguing and tends to cause congestion of the blood about the eyes. The forward position of the head throws the body out of erect balance and almost certainly results within a short time in stooped posture, leaning on the elbows (which are drawn forward so as to compress the chest) and probably resting the head in the hand. Even if posture is ignored, it is difficult to get a perpendicular view of a page lying flat before one unless it is very low, almost at the level of the knees. In this position it may be so far from the eyes that one bends back and neck and compresses chest and abdomen almost to the limit to get the visual distance short enough; or else this bending and compression follows from the difficulty of keeping the head poised over a page in such position. With increase of height the foreshortening, neck bend, and myopic strain increase. It is sometimes contended that pupils' desks should be flat-topped because office desks and tables used in the homes are so made. This view overlooks the fact that tables and office desks are intended primarily as places upon which to lay books and papers and are seldom used for the continuous sort of reading or writing required of

pupils in school. If they are so used, they should undoubtedly be sloped for the same reasons as the bookkeepers' desks were when office writing was done by hand.

For writing purposes, the flat top has an additional disadvantage in that the elbow must be at the same level as the writing hand. If this level is as low as the elbow in erect posture, the hand is too far from the eyes for clear vision, and one must stoop to attain his visual distance; if it is higher, the forward and outward extension of the elbow involves a spinal twist as well as bend, and the foreshortening and eyestrain cannot be relieved.

On the other hand, a sloped desk top, however slight the angle of inclination, to that extent reduces the difficulties mentioned in the preceding paragraphs. The greater the tilt, the less the foreshortening of the characters or the back and neck bend necessary to correct it, and the more nearly erect one may remain with the same visual clarity. The book is brought nearer to the eyes as well as into better angle, thus lessening the forward leaning or stoop necessary to attain correct visual distance. At any slope the plane of the desk top should coincide with the plane of the underside of the forearm in writing position with elbow down and close to the side. Thus correct posture is maintained in writing, the hand being brought into proper relation to the eye by bending the elbow rather than the back and neck.

Slopes for reading and writing. The correct position of a book in reading is at right angles to the line of vision as one sits erect: forty-five to sixty degrees from the horizontal, from fourteen to twenty inches from the eyes (depending on print, light, and the eyes of the reader), and approximately at the height of the chin. With adequate light falling squarely over the shoulder,

this gives the ideal visual angle and distance, the most efficient light, and correct posture. No postural or visual ills could arise from study in such position, and it is probable that the exercise would be beneficial to eyes, back, and vital organs for as long as one could sustain the mental exercise. But no one, least of all a little child, could hold a book in that position for more than a minute or two without painful fatigue. Though unimportant hygienically, arm fatigue is acute and insistent. Hence such desk top as there may be, or else the body in some bad posture, does and will serve as a book rest. The desk top can be made to hold the book in this position with the aid of the hand or some ledge to rest the book on. But for writing under modern conditions this slope would be impracticable.

For writing, the best slope appears to be approximately twenty degrees. The height should be such that as one sits erect the elbow and the underside of the forearm in writing position are in the plane of the top. Exact visual distance is not so important nor moderate foreshortening so serious as in reading, since written characters are not so fine as the printed, movement is not so rapid, and the form is foreknown to the writer and is determined largely by muscular movement. The distance may be corrected as far as necessary by further tilting the top or inclining the head. But books and papers slide off a desk sloped twenty or more degrees; hence most school desks have a somewhat lower slope, being a compromise between hygienic ideals and practical convenience.

Most school desks, therefore, are not reading desks at all. It is apparently assumed that a pupil may hold his book in a satisfactory position, but that he must

write on the desk top and lay his books and papers on it. As a choice between the two positions, the assumption is doubtless the sane and practical one.

Dresslar has insisted ("School Hygiene," p. 87) that the reading slope is also entirely practicable for writing purposes and cites the scriptoria in the medieval monasteries, where manuscript writing was a continuous occupation, as equipped with writing desks in this form. Not many would agree that they would be equally adapted for modern school use.

Many "tilting top" and "reading top" devices have been on the market from time to time, intended as a means whereby the pupil might convert his desk from a writing surface to a reading support at will. Aside from mechanical objections, these have failed in the essential object of getting from a correct writing position to a correct reading position. There is no virtue in merely uptilting the book unless at the same time it is placed at the proper height, distance, and angle for reading as one sits erect. Most of these devices involve two or three distinct and unrelated adjustments, some of them requiring wrench and janitorial assistance. It must be remembered that for one correct position, there are innumerable incorrect ones, and there is no instinctive tendency to select the right one. The guide to the correct placing of the adjustable top must be built into the device itself, and it must coincide with the line of least resistance.

Further discussion of the problems of the desk top is deferred to Chapter XV, where they will be considered in connection with various practical limitations, statistical data of pupil measurements, and anatomical facts not directly related to vision.

Sight-conservation classes. It is usual now in large schools or systems to segregate the pupils having seriously defective vision into separate classes where they are provided with the supervision and treatment of specialists, special methods of instruction, books printed in large type, and other equipment and conditions suited to their needs. The need is imperative in such classes

for desks which will insure that both writing and reading shall be done in the positions most favorable for vision. Movable desks with adjustable tops are generally used for the purpose, but the writer's observation is that they are seldom moved or adjusted in an effective manner, and are often used so that new elements of visual strain are introduced. For example, more than once it has been found that, because a pupil's eyes are very sensitive and medical authorities have warned against exposing them to strong light, the teacher has carefully placed him in the dark part of the room where books have the poorest illumination and he must *look toward the light* in nearly all his work. What should be done, of course, is to place such pupils on the light side of the room *facing* toward the dark. Backs should be toward the light, books well lighted, and pupils should literally "see the bright side of everything" at which they are required to look, including the bright side of the teacher, whose face is illuminated because she is in the dark part of the room facing the windows.

Modern methods and one-eyed writing. As a result of growing appreciation of school hygiene the earlier custom of having pupils write with the right side toward the desk has been generally abandoned as directly productive of both scoliosis and eyestrain. Modern methods of teaching writing require the pupils to face squarely forward with both arms on the desk at about the same angle, the left hand steadying the paper at the top while the right moves across the lines parallel to the left forearm and at an angle of approximately forty-five degrees to the edge of the desk. This position is sound from the postural point of view and an improvement from the standpoint of vision. There has been a long dispute,

mainly on hygienic grounds, between the advocates of slant and of vertical penmanship. Many arguments have been advanced on both sides, but the matter seems to have simmered down to the decision that, whatever may be the relative advantages in speed or legibility, either good or bad posture and visual conditions are about as probable with one style as with the other. A new problem has arisen, though not generally known, from the discovery that as one writes in the most approved position (the arm moving on the ball of the thumb and the muscle under the forearm) the point of the pen is not usually visible to the eye on the side of the writing hand. This is easily demonstrated by holding the pen in the "correct position" and closing the opposite eye. Thus right-handed persons write with the aid of the left eye only. At present the matter seems to be one of curious rather than practical interest. It may account in part for the insistent tendency to roll the hand outward, instead of resting it on the ball of the thumb, in spite of persistent correction.

This fact was disclosed by Dr. George M. Gould ("Biographic Clinics," Vol. II, chaps. vii–viii), who also claims to have found, during a long practice as ophthalmologist, that right-handed persons are dominantly right-eyed and left-handed persons left-eyed. This claim has been disputed, but, so far as I am aware, neither definitely disproved nor verified by further statistical data. There are reasonable grounds in brain anatomy for the assumption. If true, interesting implications follow. That which Dr. Gould points out is that in modern methods of writing the point of the pen is seen only by the weaker eye, being hidden from the dominant eye by the thumb and forefinger. He holds that this explains the persistence of pupils in twisting the head to the left when writing (with the right hand), and that this habitual turning of the head to the left produces a compensating

spinal curvature to the right at the thoracic level. He thus establishes a causal connection between present writing methods and spinal curvature. He concludes that writing should be done in front of the right shoulder, pupil facing squarely forward, paper square with the desk and desk top tilted at an angle of about forty-five degrees. It is not clear to the writer that this position would not introduce still another element of spinal twist and visual obliquity, perhaps as serious as that which it is designed to remedy. Whether or not there is a difference in the "dominance" of the two eyes comparable to that between the two hands, it is significant that the point of the pen in approved position is seen by but *one* eye. The difficulty of controlling movements along the line of vision by one eye is well known and may complicate the problem of learning to write.

CHAPTER VIII

RESPONSIBILITY OF THE SCHOOLS

Sitting a school problem. Sitting posture is peculiarly a school problem in a threefold respect: (1) School life is predominantly sedentary not only during school hours but during many hours besides. (2) School sitting is peculiarly rigid and fatiguing. Seats are uncushioned and hard; pupils are not free to move at will, nor have they the relief of a constant play of muscles like an operative at a machine, but always the same set of sitting-muscles are in use in much the same way. (3) School age is peculiarly a formative period: bones, muscles, and habits are plastic and are getting the permanent set which is to characterize them through life. Frailties of infancy are overcome or developed into permanent defects during this age.

As early as 1737 the school regulations of the princedom of Braunschweig-Lüneburg denounced as "unwholesome and injurious" the prevalent "bending of the spine in sitting, as this compresses the intestines and gives rise to numerous complaints which are then ascribed to study; also bringing the face too near the paper, since this produces dimness of vision, a defect quite prevalent among the learned." In 1789 Johann Peter Frank, in "A Complete System of Sanitary Police," speaking of schools said: "The desks and seats deserve special consideration. They must conform to the pupil and have comfortable and not too perpendicular backs if deformities of the spine are to be avoided."

Despite these early prophets, generations passed, and the influence of Horace Mann and Henry Barnard was felt before

much thought was given to the matter. After 1860 a large number of investigations were made in the schools of Germany, Austria, and Switzerland, and much statistical matter of more or less value was accumulated relative to the prevalence of spinal curvature and myopia among school children. It was quite generally agreed that both these defects were not only aggravated but directly caused by school seating conditions. There followed many regulations and edicts intended to remedy the evils. Seats and desks for which great hygienic claims were made were devised and introduced in large numbers, officially and unofficially; but the extension of education complicated the problems faster than new devices solved it. In preceding chapters we have noted the unanimity with which school seats and desks have been condemned by the highest authorities to the present day as "instruments productive of deformities." As expressed by the distinguished hygienist Burgerstein, "The bugbear of school hygiene for a long time has been the school desk."

In 1867 Dr. Herman Meyer, in his "Mechanik des Sitzens," presented a notable study of the mechanics of sitting posture, which has influenced much of the subsequent literature. Still earlier (1863) Fahrner described the prevalent writing posture as follows:

> As soon as the writing begins all the children move their heads slightly forward and towards the left, without perceptibly altering their attitude in any other way. Soon, however, head after head drops down with a rapid jerk so that the neck now forms a considerable angle with the rest of the spinal column. In a short time the upper part of the back also collapses, so as to hang from the shoulders, which in turn are supported by the upper arm.

It is unnecessary to follow Fahrner's detailed description of the progressive stoop, twist, and postural collapse to realize that what he observed in Germany more than sixty years ago is largely true in American schools today. Elsewhere we have indicated other characteristic methods by which pupils in various unwholesome slumps and contortions seek to adjust themselves to difficulties of vision and the discomforts of sitting in both reading and writing.

Geradhalter. A characteristically Prussian method of securing erect posture and avoiding the eyestrain and spinal contortions incident to school work was the *Geradhalter*, used in the central European countries a couple of generations ago. This was a device which either strapped the child's shoulders to an upright at his back or held his head away from the desk by some sort of yoke or other "instrument of torture" against his breast, neck, chin, or face. Cohn himself required his own children to use such devices in all their writing both at school and at home.

Standing at work. A more rational method of avoiding bad sitting posture was frequent among the Germans; namely, providing desks which could be readily converted from sitting to standing height and requiring an alternation of sitting and standing of pupils at their studies. This plan has much to commend it hygienically, but appears to be unknown in American schools, where standing is becoming a lost art. Pupils no longer stand in line for recitations, less and less often does one stand at his seat to recite when called upon, and punishment by standing one in the corner is regarded as a barbarous antiquity. There are, of course, excellent educational reasons for this decrease of occasions for standing, but the fact makes the problem of hygienic sitting all the more insistent.

However wisely or necessarily so, sitting has become the central physical fact of school life. We have seen that it is a central fact in physical vigor and development.

Opinions versus facts. The literature of the subject abounds in descriptions of unhygienic sitting positions of children in school and assertions of the responsibility of seats and desks in general or of particular types and conditions of them for prevalent bad posture. There can be no doubt that in the opinion of students of school hygiene bad posture is general, that it is an effective cause of the physical ills which we have described in previous chapters, and that it is the direct result of

prevalent seating conditions. Unfortunately there has been little done in the way of definite statistical studies to substantiate these opinions. The conclusions are doubtless valid, but what is necessary to make them conclusive and convincing is an extensive tabulation of the facts. There are needed extensive records of actual posture classified on some standard basis which gives comparable records, with the fullest possible data as to conditions of lighting, of training, and of types, dimensions, and adjustments of seating. It is hoped that many studies of this sort will appear, but their cumulative value will be slight unless care is taken to make them strictly comparable. The data of this chapter will at least afford a starting point for criticism and further development. It presents some beginnings of such studies which have been made.

Boston studies. In 1901–1902 Lilian M. Towne reported to the Public School Section of the Boston Physical Education Society an extended coöperative "Study of Pupils' Attitudes" in schools in and near Boston.[1] The classification of sitting postures observed follows:

(1) Good position. (2) Front position (trunk erect): (*a*) knees in desk, (*b*) sitting on foot, (*c*) leaning on elbow — all with chest flat. (3) Forward position: shoulders rounded. (4) Bending position: uneven shoulders. (5) Twisted position: (*a*) entire trunk twisted, (*b*) pelvis front, shoulders twisted. (6) Sliding-down position: (*a*) shoulders front, (*b*) shoulders twisted.

The positions of 1484 different pupils were reported four times each day for one week, disclosing the following facts: positions observed were 13 per cent good, 40 per cent non-erect, 13 per cent sliding down, and 23 per cent twisted. Bracing knees in desk was seven times as common among boys as among girls; sitting on the foot was two and one-half times as common

[1] *American Physical Education Review*, March, 1901, and March, 1902.

among girls as among boys, ceasing in the sixth grade for boys but never for girls; leaning on elbows did not occur in primary grades but increases in the higher grades and is twice as common among girls as among boys; bracing the feet in the desk irons increases through the grades, being three times as common among girls as among boys in the higher grades; complexity of positions, twisted positions, and good positions increase in frequency through the grades. It was remarked that weather affects posture, that morning hours are better than afternoon hours, and that posture is better in some subjects than in others, being especially faulty in sewing and busy work. Positions tend to be constant for the same pupils; for example, one boy in the fourth grade in twenty observations was sliding down in eight and in the forward position in seven.

No data are given as to the types of furniture used nor their adjustment to the pupils observed.

Gladys Abbott [1] reported an informal observation of the posture of pupils in a classroom having deficient and trilateral lighting, in which she noted that most of the pupils were forming scoliotic posture habits that varied in form according to the direction from which the best light came to their desks. We find no other objective or quantitative studies of this particular problem.

Method and scope of present study. In the spring of 1924 the writer attempted to secure a bird's-eye view of schoolroom postures and some of the factors which determine them. Four thousand six hundred and thirty-seven individual records were made in elementary and high schools at or near The University of Chicago.

Record cards were prepared for these observations, a sample of which is here presented. The aim was to make the record on each card as nearly as possible like an analysis of a snapshot picture of the room at a given instant. Owing to the time necessary to observe,

[1] *American Physical Education Review*, Vol. X, p. 36.

School Room Grade Date Time Part of Period

Occupation: Read. Writ. Rec. No. of Pupils $\left\{\begin{matrix} B \\ G \end{matrix}\right.$

Type of Seating Adjustable $\left\{\begin{matrix} \text{Desks} \\ \text{Seats} \end{matrix}\right.$

Spinal Profile	Lateral		Elbow Sup.		Head Sup.		Vis. Dist. Short	Illum. Bad	Seat		Desk		Spacing		
	R	L	R	L	R	L			High	Low	High	Low	+	−	0
A^{B}_{G}															
B^{B}_{G}															
C^{B}_{G}															
(Erect)															
D^{B}_{G}															
E^{B}_{G}															

Training

Lighting

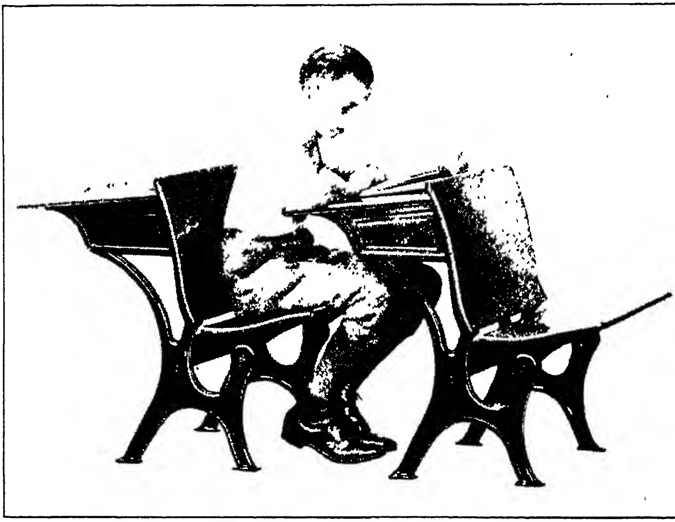
Seat Comfort Knee Clearance Desk Slope Oak Maple

Condition of Furniture: Good Old Scratched Cut Broken Writ. Surf. Rough

Remarks:

Observer

classify, and record the position of each child, and to the frequent movements of the children, particularly as the observer's purpose was sometimes discovered by the pupils, it was impossible to make a full analysis of the posture of every child. Attention was therefore



A

FIG. 21. Spinal profile A, forward stoop; spine sagged at lumbar level, shoulders drawn forward, chest compressed, upper weight supported from shoulders, which are sustained by elbows resting on desk. Forward bend at waist instead of at hips

concentrated on getting an accurate record of that phase of the sitting position which we have designated as the "spinal profile."

Spinal profiles. Five designations of spinal profile were used, three (A, B, and C) in which the spine was sagged or slumped and two (D and E) in which it was erect.

Profile A may be described as that in which the child

is stooped forward, shoulders rounded, head down, chest flat and compressed, pelvis tilted back, lumbar curve reversed, and forward bend at waist instead of hips (Fig. 21).

Profile B is that in which the child's general position is vertical, but with spine sagged, back muscles relaxed and stretched, the lumbar curve reversed, and chest and abdomen compressed (Fig. 22).

B

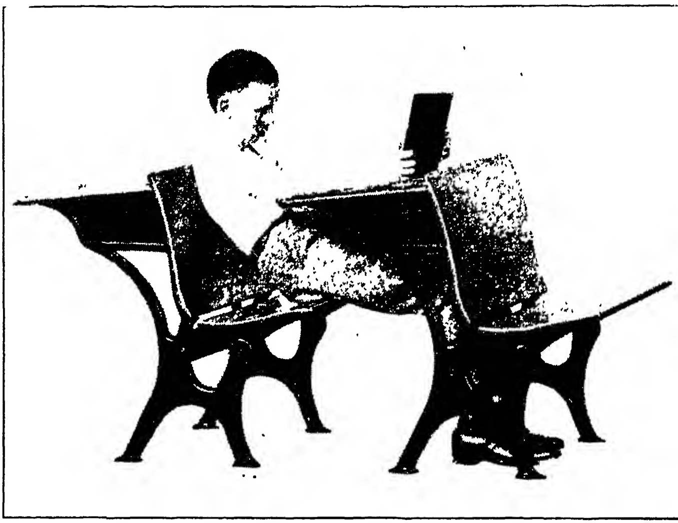
FIG. 22. Spinal profile B, vertical stoop; spine sagged, shoulders drooped forward, chest and abdomen compressed. Backward tilt of pelvis is indicated by white string on seat which marks position of ischial support, and chalk mark on garment which indicates top of hip. A characteristic posture of girls

Profile C is that in which the same general conditions are seen as in the foregoing, but the child has slid down in his seat, with shoulders supported by the back of the seat, the pelvis tilted far back, and the weight thrown largely on the coccyx and sacrum (Fig. 23).

Profile D is that in which the child sits erect upon the ischial bones, chest and abdomen reasonably expanded, the spine preserving its natural curves and sustaining the weight of the body (Fig. 24).

Profile E differs from D only in that the child is leaning forward to work on his desk. The spine is erect and

carries the weight except so far as it may be partly supported by the arms while writing or holding a book on the desk. The forward bend comes at the hips and not at the waist, as it does in the forward stoop (Fig. 25).



C

FIG. 23. Spinal profile C, backward slump; spine sagged between the supports at its two ends, shoulders drawn forward, thorax and abdomen heavily compressed, neck projected far forward of spinal line, neck and back muscles stretched to limit. Position particularly common among boys

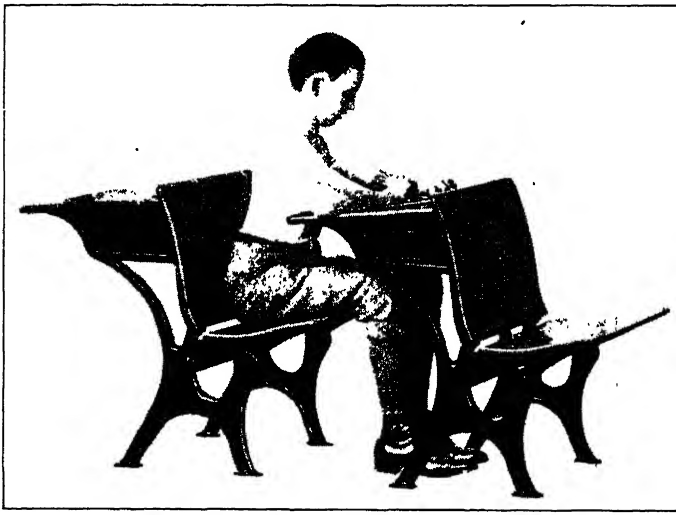
Since the erect profiles D and E sometimes include postures objectionable because of some lateral twist or curvature, or because of an unhygienic asymmetrical support on the elbows, the actual proportion of *good* posture is less than that shown by the figures. It is also to be noted that the entrance of a visitor to the room and consciousness of his close observation cause many children to sit better than they otherwise would. For these reasons the results are more favorable than the actual facts.

Naturally, no records were made when the class, as a whole, was at the time required by the teacher to sit erect. Many recorded observations, however, were made shortly after the class had been called to "attention" or "position," and the calling of individual pupils to position, or directions to "sit up" often occurred during the observation. Such commands, to be sure, improved the posture in the room, but it is to be assumed that they occur with sufficient frequency to affect the average posture which it was our purpose to observe. Frequently there was difficulty in classifying the spinal profiles on account of clothing, the equivocal character of the position, or change at the instant of observation. A little experience enables one to verify his judgment of the spinal profile from the position of the shoulders and the poise of the head. In case of movement the general policy was adopted of passing the individual until he had settled himself in some position. Most pupils soon assume the posture that has become habitual.

D

FIG. 24. Spinal profile D, vertically erect; spine functioning as a column, carrying upper weight and resting on vertically balanced pelvis. String on seat shows position of ischials and chalk mark on garment shows crest of hip. Lumbar curve normal and supported by lower back support. No pressure against buttocks from either below or behind. Arms were drawn forward to show back position, but in this posture shoulders would hang back and down by their own weight. This is a position of complete relaxation below the neck

Statistics of posture observations. Table I presents the recorded data classified by spinal profile, sex, and school grade. From Table II, which is the data of Table I converted into percentages, we find that in 59 per cent of all observations the posture was definitely bad; that is,



E

FIG. 25. Spinal profile E, forward erect; spine functioning as column and carrying upper weight, lumbar curve normal, thorax and abdomen expanded, forward bend at hips and not at waist. Back muscles short and relaxed; the slight forward leaning of the trunk is offset by the support of the arms on the desk

stooped, being slightly worse among the girls (60 per cent) than among the boys (58 per cent). The boys show a 50 per cent greater tendency to slide down in the seats (profile C) than do the girls; the other two stooped profiles (A and B) are more common among the girls. The vertical erect posture is the same for boys and girls.

TABLE I. POSTURE ACCORDING TO SPINAL PROFILE OF 4637 INDIVIDUAL PUPILS CLASSIFIED BY SEX AND GRADE[1]

GRADE	PROFILE A		PROFILE B		PROFILE C		PROFILE D		PROFILE E		TOTALS		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
I	47	33	77	94	27	28	91	84	38	31	280	270	550
II	19	29	58	48	38	17	75	81	20	17	210	192	402
III	54	50	75	67	31	28	79	77	25	23	264	245	509
IV	30	29	84	85	34	26	64	55	28	16	240	211	451
V	30	31	59	97	28	18	85	93	27	32	229	271	500
VI	56	91	89	114	35	22	73	89	33	43	286	359	645
VII	35	64	76	99	16	15	69	56	28	22	224	256	480
VIII	28	49	96	89	20	16	50	47	35	22	229	223	452
High school	26	39	57	156	36	38	55	112	43	50	217	395	612
Subnormal	3	3	17	6	1	1	3	0	1	1	25	11	36
Total	328	418	688	855	266	209	644	694	278	257	2204	2433	4637

SUMMARY FOR ALL GRADES

	Boys	Girls	Both
Bad profiles: A, B, and C	1282	1482	2764
Good profiles: D and E	922	951	1873
Total observations	2204	2433	4637

The best average posture is among first-grade girls (51 per cent good) and the worst among seventh-grade girls (70 per cent bad). Dividing the table between the sixth and seventh grades we find the proportion for boys precisely the same in the lower grades as in the higher (42 per cent good), but the girls show 41 per cent good in the lower grades and 35 per cent good in the upper.

As stated, these figures relate only to stooped posture; but, taken in connection with the well-established fact that scoliosis is far more prevalent among girls than among boys and that it increases in prevalence from lower to higher grades, there appears to be urgent need

[1] For explanation of spinal profiles A, B, C, D, and E see pages 90–91.

TABLE II. DATA OF TABLE I CONVERTED INTO PERCENTAGES

GRADE	PROFILE A		PROFILE B		PROFILE C		PROFILE D		PROFILE E	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
I	17	12	27	35	10	10	33	31	13	12
II	9	15	28	25	18	9	35	42	10	9
III . . .	20	20	28	27	12	12	30	32	10	9
IV	12	14	35	40	14	12	27	26	12	8
V	13	12	26	36	12	7	37	36	12	12
VI	20	25	31	32	13	6	25	25	11	12
VII . . .	16	25	34	39	7	6	31	21	12	9
VIII . . .	12	22	42	20	9	7	22	21	15	10
High school	12	10	26	39	17	10	25	29	20	12
Subnormal	12	27	68	55	4	9	12	0	4	9
All grades	15	17	31	35	12	8	29	29	13	11

SUMMARY FOR ALL GRADES

	Boys	Girls	Both
Bad profiles: A, B, and C. All grades . . .	58	60	59
Grades I–VI	58	59	
Grades VII–XII	58	65	
Good profiles: D and E. All grades	42	40	41
Grades I–VI	42	41	
Grades VII–XII	42	35	

of a thorough study of sex differences as related to seating, physical training, and whatever other factors may be affecting the posture of girls in school.

Effect of occupation on posture. An important factor in posture is the kind of occupation in which the pupil is engaged. While there are many variations and combinations of employment, four distinct types were recognized, and the record was made according to the type which was dominant in determining the sitting-position at the time of observation. As a rule the type of work was regarded as the same for all members of any class or group

working together as a unit. The types of work were distinguished as follows:

1. *Reading,* including all book study in which the child's eyes and attention were focused upon printed matter, wherever held.

2. *Writing,* in which position is determined by the fact that the child is writing upon the desk top. No distinction was made between ordinary writing or figuring, in which pupils were unconscious of their position, and formal-penmanship exercise, in which maintenance of good posture commonly constitutes a large part of the instruction. If such distinction between spontaneous and prescribed writing positions were made, the former would make a considerably poorer showing. Map-drawing and other desk work is here included.

3. *Recitation,* in which the attention of the pupils is directed primarily upward toward the teacher or the blackboard.

4. *Manual activities,* including all construction and similar work in which pupils are manipulating objects on the desk.

From Tables III and IV it is seen that posture was worst in reading and writing activities, which constitute the larger part of school work, being the same (65 per cent bad) for both reading and writing. During typical recitation activities the proportion of bad posture drops to 57 per cent, and in construction or manual activities it falls to 39 per cent. The last figure represents primary classes almost exclusively. If a large number of sewing classes could have been included, the result would probably have been quite different.

Effect of fatigue on posture. In order to determine to what extent fatigue affected the sitting position, the time of

Table III. Posture classified by Occupations[1]

Occupation	Profile A		Profile B		Profile C		Profile D		Profile E		Totals		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
Reading . . .	37	65	110	132	75	53	98	94	29	35	349	379	728
Writing . . .	167	187	213	263	54	43	128	141	124	105	686	739	1425
Recitation . .	115	153	330	409	132	107	339	382	111	98	1027	1149	2176
Manual activities	9	13	35	51	5	6	79	77	14	19	142	166	308
Total	328	418	688	855	266	209	644	694	278	257	2204	2433	4637

Table IV. Data of Table III converted into Percentages

Occupation	Profile A		Profile B		Profile C		Profile D		Profile E	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Reading	11	17	31	35	22	14	28	25	8	9
Writing	25	24	31	35	8	6	18	22	18	13
Recitation	11	13	32	36	13	10	33	33	11	8
Manual activities . .	6	8	24	31	4	4	56	46	10	11
Total	15	17	31	35	12	8	29	29	13	11

SUMMARY

	Bad Profiles: A, B, and C			Good Profiles: D and E		
	Boys	Girls	Both	Boys	Girls	Both
Reading	64	66	65	36	34	35
Writing	64	65	65	36	35	35
Recitation	56	59	57	44	41	43
Manual activities	34	43	39	66	57	61

day at which each observation was taken was noted. Table VI shows that bad posture increased from 54 per cent in the morning hours to 66 per cent in the afternoon. Record was also made whether the observation was made in the first or latter half of the class period. Table VIII indicates that posture was very slightly

[1] See p. 97 for definitions of occupations.

better in the latter half of the period. The difference, however, is too slight to be regarded as significant.

TABLE V. POSTURES CLASSIFIED ACCORDING TO TIME OF DAY

	Profile A		Profile B		Profile C		Profile D		Profile E		Totals		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
Morning . .	139	187	320	383	128	93	390	397	142	139	1119	1199	2318
Afternoon .	189	231	368	472	138	116	254	297	136	118	1085	1234	2319
Total . .	328	418	688	855	266	209	644	694	278	257	2204	2433	4637

TABLE VI. DATA OF TABLE V CONVERTED INTO PERCENTAGES

	Profile A		Profile B		Profile C		Profile D		Profile E	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Morning	13	16	28	32	11	8	35	33	13	11
Afternoon	18	19	34	38	13	9	23	24	12	10
Total	15	17	31	35	12	8	29	29	13	11

SUMMARY

	Bad Profiles: A, B, and C			Good Profiles: D and E		
	Boys	Girls	Both	Boys	Girls	Both
Morning	52	56	54	48	44	46
Afternoon	65	66	66	35	34	34

TABLE VII. POSTURES CLASSIFIED ACCORDING TO THE PART OF THE PERIOD IN WHICH THE OBSERVATION WAS MADE

Part of Class Period	Profile A		Profile B		Profile C		Profile D		Profile E		Totals		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
First	142	155	270	357	103	95	235	292	111	117	861	1016	1877
Latter . . .	186	263	418	498	163	114	409	402	167	140	1343	1417	2760
Total . .	328	418	688	855	266	209	644	694	278	257	2204	2433	4637

TABLE VIII. DATA OF TABLE VII CONVERTED INTO PERCENTAGES

Part of Class Period	Profile A		Profile B		Profile C		Profile D		Profile E	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
First	17	15	31	36	12	9	27	29	13	11
Latter	14	18	31	35	12	8	30	29	13	10
Total	15	16	31	35	12	8	29	29	13	11

SUMMARY

	Bad Profiles: A, B, and C			Good Profiles: D and E		
	Boys	Girls	Both	Boys	Girls	Both
First part of period	60	60	60	40	40	40
Latter part of period	57	61	59	43	39	41

Other desirable data. It is extremely desirable and was originally intended as part of this study to secure data from which to reach conclusions as to the effect on posture of lighting conditions and particularly of the types and adjustments of the furniture in use. While some significant facts in relation to these matters were recorded and it is planned to supplement them later by more extended observations, the data in hand are too incomplete and too involved to justify a presentation of such tentative analysis as can now be made.

Blanks are provided on the card record for notations as to postural or general physical training, as well as for lighting conditions which might affect the standards of posture in any particular room or school. The last three lines are intended for use in making a survey of the seating equipment whenever it may be desired to include this aim in making observations.

CHAPTER IX

THE TEACHING OF SITTING POSTURE

A neglected duty. Training in the art of sitting is apparently a neglected aspect of the physical-culture program. Quite naturally, physical-training teachers do not use their gymnasium hours or apparatus to practice pupils in sitting still. There is enough and too much of that in the other school periods. So far as may be judged from literature and observation, the occasional instruction and references to proper sitting are not such as carry over effectively into daily and all-day-long practice, and teachers of physical training would be the last to hope for effective results from precepts which are not followed up with practice. As physical supervisors they do occasionally attempt to superintend the adjustment of seats and desks in behalf of better posture, but, as will be mentioned elsewhere, without much success. Classroom teachers of the better sort prevent the extremes of slouchy posture, many of them often echo the refrain "sit up," some of them accomplish worth-while training by frequently calling the class to "position," and a very few seem to have found a way to secure definitely a fairly high average of continuously good posture. In general, however, the facts are about as shown statistically in the preceding chapter, or worse. School sitting is predominantly bad.

A divided responsibility. To be fair, training cannot hope to be effective so long as equipment is positively

antagonistic. Instruction and exhortation alike will be largely in vain so long as tired muscles, long hours, and hard boards conspire to their defeat. The responsibility for the posture of school children must be shared by manufacturers of seating equipment, whose duty it is to make seats in which right posture is not only possible but most comfortable; by school executives, who must see that properly shaped and proportioned equipment is installed; by physical trainers, who should instruct and inspire pupils with right ideals of sitting posture; and by classroom teachers, who should see that pupils are seated appropriately to their individual needs and that pupils do their part in forming ideals into permanent habits. Equipment must make habitual good posture possible; instruction and training must make it a reality.

A program needed. A systematic program and technique of training in sitting posture is demanded. This is not to supersede the various systems of corrective exercises which seek to remedy stoop, scoliosis, and other postural defects. What is needed is a constructive program which will prevent these defects so far as school life is a factor and will make erect, wholesome sitting the most comfortable, natural, and habitual from the beginning.

The training phase. A program of the sort divides obviously into two phases: instruction and training. The latter will be, in the main, the responsibility of the classroom teacher and will consist (assuming that the seating equipment has made it practicable) in holding pupils to the ideals which they have learned. As in all teaching which seeks to make right practices habitual (for example, in writing, spelling, and the language arts),

the larger part of the teaching of posture is in the constant following up of instruction and requiring pupils to practice the best they know until that best becomes the most natural. No special occasions, exercises, or practice periods are required, since sitting is an inevitable part of nearly all school work. If training is begun early and followed up wisely, a minimum of attention and effort on the part of the teacher or pupils will be required; if begun late or neglected, corrective as well as constructive work is necessary, and this demands more of skill, time, and energy.

Instruction. The instruction required is for the most part (1) the physiological knowledge contained in the preceding chapters, suitably simplified, supplemented, and adapted to the several stages of pupil development; (2) motivated throughout by appropriate appeal to instinctive impulses; and (3) rendered very practical by a simple technique or set of rules for sitting which pupils can put into practice with the least confusion and surest results.

Suggestion in primary grades. In the primary grades instruction is necessarily less analytical or factual and more suggestive. Little boys readily respond to the suggestion that they "sit up straight like soldiers" so that they will grow big and strong, and little girls as readily accept the idea that they look bright and pretty when they sit straight. Those who sit best are praised and pointed out as models, though a sympathetic teacher will not fail to lay emphasis on effort and erect habit rather than on mere physical superiority. Of course, John will sit well because he is so strong and sturdy, but see how well Willie is sitting, and he isn't nearly so strong yet. But he will be strong and straight if he sits well and takes good

care of himself in every way. Mary feels so strong and well that it is just fun for her to sit up like a lady, and Lily is getting strong and rosy because she sits that way. Sitting like this gives the lungs plenty of room to make lots of good red blood and gives the heart a chance to send it into the cheeks and all over the body. We must keep these muscles in the back strong so that they will hold us up straight. If we keep stooped over, they stretch out and become weak like an old worn-out rubber band.

Physical aids. Children of this age who have real difficulty in sitting erect may require medical attention. They may be anæmic, rachitic, or tubercular. There will be others whose coördination is not good or who, through timidity, self-consciousness, and related psychological causes, are unable to respond effectively. In the effort to sit straight they merely lift the shoulders, protrude the abdomen, stiffen into varied grotesque positions, or are perhaps helplessly bewildered. A gentle manipulation of the shoulders (back and downward), a soothing pressure in the small of the back, or a stimulating and encouraging patting on the chest may get the child into the position where he gets the feel of real erectness. Overinsistence will increase self-consciousness and the difficulty of making a good position natural. Slow, deep-breathing exercises help both to correct the position and to relax tensions. It is all-important that the erect posture should be thought of as a comfortable, pleasant, and enjoyable position. It is not a task nor a corrective discipline, but a condition favorable to enjoyment, and should be associated with getting ready to play, march, sing, or listen to stories. It is not a stiff or strained position but one of easy poise.

Except for such helpful suggestions and assistance, the little child should not be made conscious of the physiological mechanics or technique of erect posture. Remember the classic example of the centipede who had no trouble in managing his numerous legs until the mischievous frog rendered him helpless by raising the question as to *how* he did it. Children learn to stand, walk, run, and manipulate objects, not by analysis but by trial and error, which is a gradual selection of effective from innumerable ineffective movements. The learning principle is the same in sitting, with this difference that the criterion of effectiveness is not in the process itself, since the sitting purpose is accomplished however awkwardly and unhygienically the children sit. The criterion is artificial so far as present needs are concerned, hence approval and commendation must take the place of mere success as an incentive to persistent effort.

Good seating. If properly designed and proportioned seats are available, not too high nor too deep, suitably sloped, with no elevation at the rear of the seat to slide the ischials forward, and with backs formed to fit well and comfortably into the lumbar curve, it is only necessary for the child to slide well back in his seat and relax, in order to get the feel and the fact of correct posture. With this aid he can easily understand the essentials both of right posture and of a suitably fitted seat. These essentials are that when he sits with feet squarely on the floor there is *no* pressure under the knees, that he gets full and comfortable support for the back without slumping, that there is no tendency to slide forward on the seat, and that when he relaxes, the shoulders tend to hang outward and back with no inclination of the body to topple forward. It is a very simple matter to teach good posture

if the seating equipment is right, but very difficult if the seats make good posture awkward or impossible.

Higher physiological instruction. As pupils grow older, instruction in the physiology of posture becomes more definite and should properly be correlated with or embodied in the systematic teaching of physiology. It is to be hoped that physiology texts will be modified to present more adequately the facts relating to posture. In the study of the skeleton emphasis is to be laid upon the supporting function of the pelvis and the spinal column. Structural mechanics should be taught so as to make it clear that the body weight can be carried without muscular strain or effort only when the pelvis is vertical and the spine, functioning as a true supporting column, places the weight upon the head of the sacrum; that the normal spinal curves are essential to its great columnar strength combined with its marvelous flexibility. The central position of the spine in the body with the perfect distribution of organs and weight about it when the trunk is erect, head poised, and shoulders hanging well back, is of special importance. The part that the muscles of the back and shoulder girdle play in poise and posture should be made impressive, and emphasis upon the development of muscular *strength* through exercise should not obscure the importance of maintaining the *tonus* of these muscle systems by avoiding habitual stretching and by keeping them short and elastic. The necessity for full thoracic and abdominal space for the development and free functioning of the vital organs should be more persistently stressed, as well as the danger arising from these organs being compressed and crowded down upon each other. The nicely balanced arrangement of the larger organs and the beautifully adjusted supporting devices by which

they are held in position in a vertical cavity are scarcely alluded to in the texts, nor are the strains and displacements of them which result from habitual stooped or asymmetrical posture. For the older girls few if any lessons that the school can teach are of more importance than the effects of these displacements in the ills and lowered vitality of women, the direct relation between female posture and health, a vivid presentation of the contribution of a habitual erect position of the pelvis to health, comfort, and safety in the perils of maternity.

Throughout such physiological instruction emphasis should be laid on the early and gradually decreasing plasticity of the bony system, which fact places the responsibility of adult posture and carriage upon the habits and will of childhood. Similarly, the principles of habit formation as applied to muscular development should be stressed both as a direct influence in posture development and as a background for psychological instruction. Indeed, the whole physiology of posture as taught to children should afford an admirably concrete and tangible foundation for the teaching of the many important lessons regarding differences between children and adults — lessons which are especially significant but difficult to teach in relation to the use of narcotics and stimulants.

Motivation. Motivation of posture instruction and training by appeal to instinctive tendencies will, of course, vary with the development of pupils and the circumstances of instruction, but no subject of instruction has a surer ground of appeal. To boys the ideals of strength, vigor, virility, of athletic and occupational efficiency and success, of commanding presence and soldierly bearing are unfailing if effectively used. To girls the ideals of gracefulness in carriage and posture, of feminine beauty and

attractiveness, natural loveliness of complexion, health and the continuing ability to enjoy life and remain young, freedom from the lingering pains and depressions so common to women, provide unequaled motivation. And these are not strained or far-fetched motives, nor do they consist in doubtful promises, for these rewards are visible on every hand in connection with good posture and seldom without it.

A technique of sitting. School seats should be so well adjusted and proportioned that it is only necessary to sit well back in them to be assured of good posture, but this is far from true of most of them or of the many other seats which one occupies. It is necessary, therefore, that there be developed a conscious technique of good sitting which will serve under all circumstances to counteract the evils of badly formed or fitted seats. It is not meant that one should at all times sit erect or at any time stiffly and uncomfortably so, but that every intelligent person should at least be entirely aware of when his posture is wholesome and graceful (as apparently few are now) and be able to control the formation of sitting habits and to choose seats that are properly formed or to avoid unnecessary fatigue and discomfort in the badly formed ones to which he is subjected.

The essentials of an erect posture, then, are a vertical position of the pelvic bones carrying the weight directly on the ischials, steadied and somewhat relieved on a hard seat by the thick muscles of the upper thighs, the spine functioning as a poised column with the weight distributed about it. This inevitably involves the preservation of a normal inward curve of the spine at the lumbar level, and the easy backward hang of the shoulders, favorable to deep breathing. In this position chest and abdomen

are naturally expanded but not awkwardly stuck forward. The head also balances easily and gracefully without fatigue of the neck or its ungainly forward stretching. The position is alert, ready for movement in any direction, and involves a minimum of muscular straining. If seat and back support are right, one should be able to relax every trunk muscle in this position without any tendency to slump or loss of erectness. When one is working on a desk surface, the back support must be nearly vertical to function effectively; for more complete relaxation a greater slope of seat and back together permits a still more restful body poise.

This best posture is simple to teach because each of its essential conditions is practically inseparable from the others. If the pelvic bones are erect, the spine must be, or one falls forward (unless he is leaning against a desk or similar support). If the lumbar curve is properly maintained, the pelvis must be erect, and the shoulders will of their own weight hang back and down. One's shoulders cannot so hang unless the spine and pelvis are erect and the thorax and abdomen are expanded. The back muscles are short if these other things are true, and vice versa. It is not an arbitrary and complex combination of adjustments, but the most natural and comfortable and perfectly poised position which the body can assume in erect sitting. We cannot too strongly insist that the position we have sought to describe is, when it becomes habitual, the most comfortable and least fatiguing in which it is possible to maintain a vertical position of the trunk. Any sagged or slumped position involves a forward stoop, which is essentially a "leaning on the viscera" and includes a straining of the back muscles, with loss of the supporting function of the spine. It is

unnecessary to repeat here the contributing causes and the penalties of this habit, but no pupil subject to it should be allowed to remain in ignorance of the price which he must pay for its indulgence.

Learning by application. These, briefly, are the things which should be taught children as to sitting-posture. In attempting to apply these lessons they will soon learn that good posture is extremely difficult, if not impossible, in a seat which is too high or too long from front to back or which is hollowed so that it slides the ischials into a tilted position. They will find that some backs will support them in good position as they sit erect, some only as they lean backward, and that many afford support only at the price of a sagging of the spine at the lumbar level. In many seats erect posture is possible only by ignoring the back support entirely.

They will find that if a desk top is too high and the elbows must be extended widely in order to write upon it, the shoulders cannot hang down nor the thorax remain expanded, and that there is an irresistible tendency to slump forward on the desk. They will find that if the desk is flat or too low they must lean over upon it to see their work clearly, and that a good position cannot be maintained in reading except by holding the book at a considerable angle from the desk top and perhaps elevating it above the desk. In this way posture training, instead of being a continuous nagging on the part of teachers and rebellion on the part of pupils, may reasonably take the form of intelligent inquiry into the factors that hinder good sitting, such correction as may be possible through reassignment or readjustment of furniture, and the sort of bodily adjustment to ill-proportioned seating that is necessary in most out-of-school sitting.

CHAPTER X

EQUIPMENT AND METHODS USED IN MEASURING

Source of data. During the years 1924–1925 the writer measured more than 3700 children, by methods to be described, as follows: more than 600 in the University of Chicago Elementary and High schools, 400 in the New Trier Township High School at Winnetka, Illinois, 500 in the Gordon School at Cleveland, 600 in the Ferguson School at Philadelphia, and 1600 in various schools of Des Moines. Fifteen or sixteen anatomical measures were taken on each of these pupils, besides a record of age, grade, sex, and often of weight and the adjustment or size of the seat in use. From the measures taken five or more others are readily derived by addition and subtraction. It is the purpose of this chapter to describe the equipment and methods used and the general technique of acquiring the data. In subsequent chapters we shall present in detail the more important data and their interpretation as applied to the designing and use of seats and desks. Much of the data and many correlations having only theoretical interest are omitted.

Earlier measuring devices. In 1907 Dr. Stephani, city school-physician of Mannheim, developed and used an anthropometric apparatus consisting of a seat with movable back and arm supports and foot rests adjustable for each foot separately, with which "twenty body measures can be secured in rapid succession and accurate to the millimeter." Screw and slide devices were used for adjusting, and measures were indicated

on conveniently placed scales. This apparatus was described in various publications and was advertised for sale or rental by a German manufacturer.[1]

In 1923 Mr. R. R. Ritchie, then superintendent of grounds and buildings of the public schools of Okmulgee, Oklahoma, devised a chair with movable foot rest arranged with tension springs and a convenient scale for reading the length of the lower leg, and measured several thousand children of the Okmulgee schools with a view to determining the correct height of seats for them. His data have been included in a study prepared at Teachers College, Columbia University, as yet unpublished.

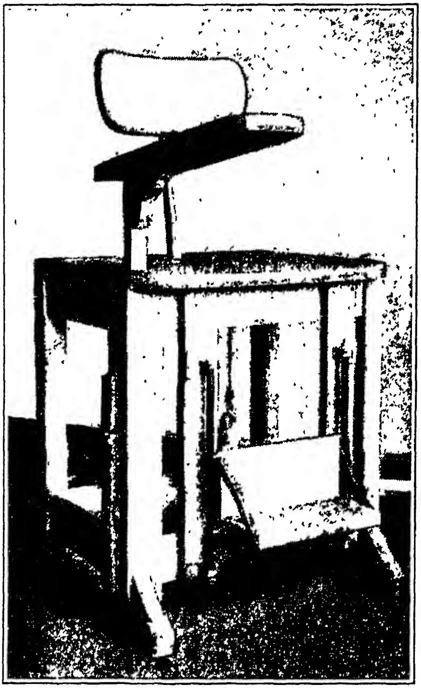


FIG. 26. Measuring-chair devised by Goss and Fraser

About the same time Mrs. Josephine A. Goss, principal of the Sigsbee School, Grand Rapids, Michigan, appreciating the need for a more accurate means of adjusting furniture to individual requirements of pupils, with the assistance of Mr. Fraser of that school, developed a measuring-chair for practical use in

[1] Stephani, Prophylaxe des Wachstums und Methode der Körpermessung (Verlag für Schulhygiene, P. Johannes Müller, Charlottenburg, 1907); *Gesund, Jugend.*, Mai, 1907; Mery et Génévrier, Hygiène Scolaire, Paris, 1914, p. 142; Handbuch über Schulmöbel der vereinigten Schulmöbelfabriken (Stuttgart, 1913), p. 182.

determining the heights to which seats and desks should be adjusted (see Fig. 26). This device has likewise a stationary seat with moving foot rest, arm rest, and back support and is equipped with scales and sliding pointers for reading the measures. It is intended as a practical measuring equipment for school use in connection with adjustable seating. It is patented.

FIG. 27. Measuring-chair used by the author. When adjusted to the pupil, the measures for record are read directly from convenient tapes and scales

Apparatus used for this study. Recognizing the need for extensive and accurate data upon which to determine the dimensions and proportions of seating equipment for schools, the American Seating Company offered to construct a special apparatus for this purpose according to plans to be prepared by the writer. After considerable investigation and experimentation, details were worked out by the engineering department of the company, and the very elaborate and expensive device shown in Figs. 27 and 28 was constructed at their expense in their factory at Grand Rapids. Although many special castings were involved, only one

of these measuring-chairs was made, and this was constructed strictly for purposes of scientific research and not for sale or other commercial uses. To the liberality of this company is due the gratitude of the writer for making this study possible as well as making its results available for the public.

The framework of the chair consists in the main of specially designed aluminum castings, and rests upon three feet, the two front feet being equipped with rollers for convenient moving. The seat is 28 inches from the floor, is 18 inches wide and 20 inches deep, sloping one inch from front to back. A moving foot rest is elevated by means of a rack-and-pinion with detachable crank conveniently placed. A similar rack-and-pinion moves vertically a framework upon which arm rests and back supports are constructed, and a third rack-and-pinion moves the arm and back supports forward and back upon the framework. The arm rests are pivoted so that they may be adjusted to the varying width of the trunk of the individual measured. The back piece consists of a vertical scaled slide upon which move two appropriately shaped forms, one of which fits into the lumbar curve at the height of the iliac crests and the other just under the points of the shoulder blades. The latter piece also slides forward and back with reference to the former, indicating the amount of curvature in the back.

Through the center of the seat, front to back, is a slot in which there slides on ball bearings a saddle block shaped to fit comfortably and accurately the ischial tuberosities. On taking his seat the subject sits on this moving block and slides as far back as the length of his thighs permits. A spring-coil tape attached to the block indicates through a convenient opening at the rear of the seat the exact position of the ischial bones, or "sitting-point." Similar tapes on spring coils indicate the position of the foot rest and the arm rests and the distance of the lumbar back support from the front edge of the seat. At the front edge of the seat is a crosswise sliding strip $\frac{1}{4}$ inch by $1\frac{1}{2}$ inches, which indicates readily to the experimenter the amount

of pressure under the knees and enables him to adjust the foot rest with accuracy. Behind the seat a vertical sliding brass rod with horizontal arm is scaled to read the standing height from

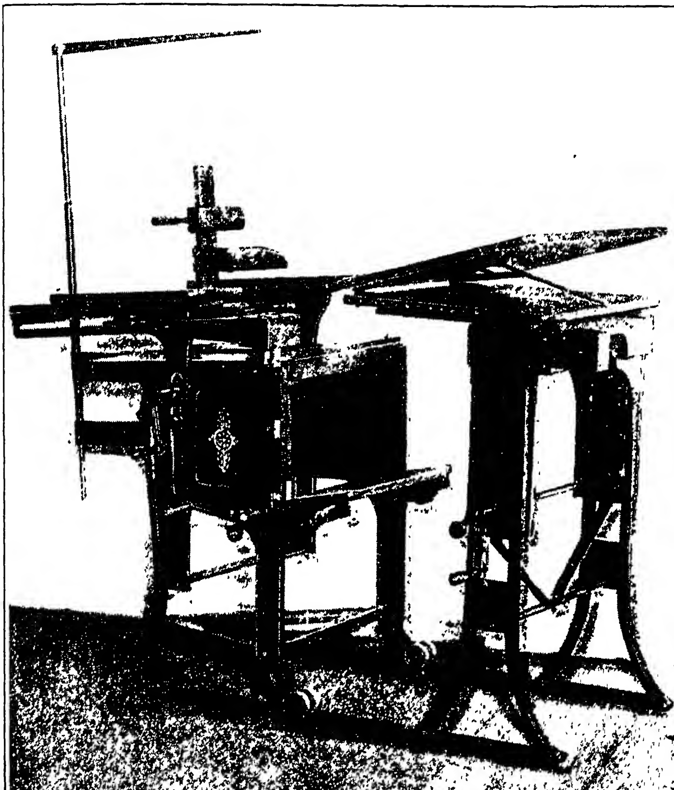


FIG. 28. Another view of the author's measuring-chair, shown with adjustable desk-top device used in connection with it

the floor as well as the sitting height and shoulder height from the seat. The entire apparatus is constructed with the best of materials, finish, and workmanship.

A supplementary device, shown in Fig. 28, provides a desk top to be used in connection with the chair. This is readily adjustable as to height, forward distance, and slope, with scales for reading each, and the top is scaled to indicate the portion which is used at various positions and in various occupations. The data derived from this portion of the apparatus does not enter into the present study.

Form of record. An individual 3-by-5-inch card, of which a sample is here shown, is used for recording the measurements taken for each pupil separately.

School ______________ Room ________ Grade ________ B or G
Name ______________ Age ________ Yrs. ________ Mos.
Weight ________ Phys. ________ Nationality ________
Seat No. ________ Ht. ________ Desk Ht. ________ Dist. ________ Type ________
Cond.

Height St. ________ Sit ________ Shoul. ________ ________ 24
A ________ ________ B ________ ________ Ka ________ Kb ________
C ________ ________ D ________ ________ R ________
________ ________ ________ ________
E ________ ________ F ________ ________
G ________ ________ H ________ ________
I ________ ________ J ________ ________

Methods. The measuring procedure is as follows: The cards are distributed to the children of a room at their seats. Each child or, in primary grades, the teacher or an assistant fills out the first two lines. The weight has been found to be of little consequence in this study and has been omitted in many cases. When conditions were favorable the children were weighed by an assistant

before being measured, or the weight was taken from recent physical-inspection cards or sometimes given from memory by older children. The blank "Phys." is used only to note a physical defect or abnormality which would account for unusual measurements. Very few such cases were found in the schools where measurements were taken. The blank "Nationality" is intended for recording such racial distinctions as may have value when a sufficient mass of material is collected. The next two lines provide the data for a survey of the seating equipment actually in use. They are filled out by an assistant with the aid of a yardstick. In the first blank stationary seats are designated according to row and place in the row. The next three blanks record, in order, the height of the seat at its highest point, the height of the desk at the near edge, and the "distance" measured from the near edge of the desk to the back support at the same level (the reason for this manner of recording the "distance" is given in Chapter XV). The type of seating and comments as to condition may be filled in as far as desired.

The measuring-chair is placed in a corridor or other convenient place as near the classroom as practicable and where satisfactory light is available. The teacher sends out three or four children, each carrying his own card filled out above the double line. It requires one or two minutes to measure a child; as each is measured he returns at once to the room, and another comes out in his place. An entire room is thus measured in an hour or two with no appreciable interruption of class work and no waiting on the part of the experimenter. In the high schools pupils have usually been taken from the physical-training classes or the study halls to avoid interruption of class work.

An assistant, seated at a table conveniently near the measuring-chair, takes down the measures as they are called off by the experimenter and keeps track of the children from the time they come out of the class-room until they return, guarding against disorder and seeing that they step up promptly when and where they are wanted. The children who are waiting are always interested in the measuring-process and, by seeing one or two others measured, know how to take their places with the least confusion or extra effort on the part of the experimenter. The assistant takes the card from each child and inspects the entries already made while the apparatus is being adjusted to the child.

The child is seated and foot rest, arm rests, and back-pieces are adjusted. The precise technique of some of these adjustments has an important bearing on results and will be presented in connection with the various data and their interpretations. The sitting-height and the height of the point of the shoulder are read by means of the sliding rod. Four conveniently arranged little windows, under which tapes automatically coil on spring rollers as the several moving parts are being adjusted, enable the experimenter to make the following readings (see Fig. 29):

Details of measurements. A, the elbow-height, or vertical distance from the surface of the arm rests at the elbow to the "floor," or moving footboard; B, the seat-length, or horizontal distance from the back support in the lumbar curve, at the height of the crest of the ilia, to the edge of the seat under the knees; C, the seat-height, or vertical distance from the edge of the seat close under the knees to the "floor," or moving footboard; D, the length of the seat from the sitting-point, or the

distance from the resting-point of the ischia on the sliding block to the edge of the seat close under the knees.

From the scales on the slide of the backpiece are read: E′, the hip-height (iliac crest) in relation to the elbow-height (A), read minus when E′ is lower than A; G, height to point of shoulder blades, measured from A; F, back slope, or horizontal difference of position between back support in lumbar concavity (at level of E′) and at G under shoulder blades, read minus if the latter is forward of the former.

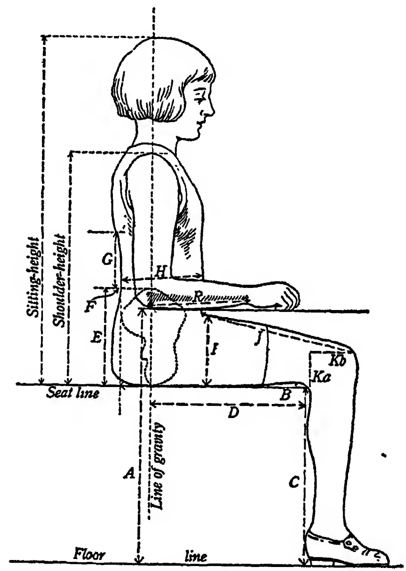


FIG. 29. Showing measurements taken

E′ and G are read in relation to A only because in constructing the chair it seemed best to build the backpieces on the frame which carries the arm rests, so that in adjusting the latter the former is automatically adjusted to very nearly its proper position. Both the construction and the manipulation of the apparatus are simplified in this way. In using the cards these figures are converted in the following manner: C is subtracted from A, giving the elbow-height measured from the seat, which is written directly under C. To this number E′ is added algebraically, giving E, the height of the hips (or lumbar curve) from the level of the seat. E′ is subtracted algebraically from G, giving the vertical distance between the hip-height and the shoulder blades, or the basic length of the back support (see Chapter XIV). Considering E as the height from the seat of the bottom of this theoretical back, the top of it is found by adding this corrected G

to the corrected E, or by adding the uncorrected G to the A–C, which has been entered just below the C. The blanks being conveniently arranged, with vertical measures in the first column and horizontal in the second column, these derived figures are written in very quickly afterwards.

By means of a light wooden scale consisting of a square with a sliding arm the following measures are taken: H, abdominal diameter at the elbow level; I, vertical thickness of the thigh taken close to the abdomen as the pupil is seated; J, length of the thigh from the abdomen to the point of the kneecap. Ka and Kb, vertical and horizontal distances, respectively, between the edge of the seat under the knees and the point of the kneecap. Finally, R, the length of the forearm from the point of the elbow to the wrist articulation, is read on a scale marked directly on the arm rest.

Accuracy. All measures are read and recorded on the cards to the nearest quarter-inch. To keep the calculations within reasonable bounds, fractions were dropped in most of the tabulations in this study.

Each one-inch interval, therefore, is actually taken at the mean of the unit and the quarter, half, and three quarters next above, which is three eighths above the unit; that is, the mean of seat-heights distributed in the 15-inch interval is 15.375 inches. All tables of these measurements should be so understood, though the spacing prevents expression of the fraction in most columns and rows.

Although less than a minute is required for the actual taking and recording of the measures of a child, owing to the convenient arrangement of the device and the complete routinization of the scoring, the apparatus measures accurately as adjusted. More time is consumed in the effort to get children to sit erect, a large portion of them apparently having no conception of how to sit straight or how to expand the chest. Our standards of position

for measuring are perfectly definite, and after some practice it was found that practically every child could be brought to them with the aid of some pressure judiciously applied to shoulders and back. The tendency of many children is to hold themselves very rigid although in an awkward and unnatural position, tenseness being mistaken for erectness. Some error in back measures doubtless arose from this source in spite of all precautions, but not such as to affect the use made of the data. It is not to be understood that all points could be determined through flesh and clothing within a quarter-inch, but that the device was set as accurately as possible and read to the nearest quarter-inch.

CHAPTER XI

SEAT-HEIGHT

The basic measure. The height of the seat from the floor is properly regarded as the measure of first importance in seating equipment. Seat and desk sizes are distinguished by the trade and are selected and assigned by educators on this basis. It is usually assumed that if the height of the seat is correct for a pupil, the manufacturers have provided that its other proportions shall be suitable. Throughout this study other dimensions will be related to this basic seat-height. Since seats have various slopes and forms, it is necessary to specify that seat-height refers to the distance from the floor of the *highest* part of the seat, which is usually near the front edge.

Anatomical determination of correct height. In comfortable and hygienic sitting the weight of the body is carried mainly from the seat bones (ischial tuberosities), upon which the weight is perfectly poised without muscular strain when one sits erect. The thick pads of muscle under the thighs are also well adapted for supplementary support. These muscles are thickest along the upper portion of the thighs, tapering downward and becoming tendons at a point from two to four or six inches above the knees. When the muscles are relaxed in sitting, these tendons are loose and function neither to carry weight nor to protect the nerves and blood vessels which lie about them between the skin and the bone. Pressure from the seat in this area behind the knees (the *popliteal*

area) tends to interfere with these nerves and blood vessels and thus becomes a cause of discomfort and restlessness, causing the feet to "go to sleep," to become cold, and possibly contributing to varicose veins and other permanent injury. The feet should rest squarely on the floor and carry the weight of the lower legs. Any pressure or support under the forward part of the thigh can function only to lift the legs and feet and does not relieve the ischials, or upper thigh muscles, of any body weight. For these reasons a seat is too high if there is any pressure against this popliteal area when the knees are bent at right angles. However slight the pressure in this area, it can serve no useful sitting function and tends positively to discomfort and injury. Any movement of the feet serves only to increase the pressure. There can be no relief except by a foot rest (which in effect is the same as making the seat lower). Pupils' efforts to escape this pressure take the form of sitting on the feet, hanging the knees against the desk edge, sliding down in the seat, or sundry ungainly and unhygienic contortions.

If the seat is too low, the knees lift the thighs from the seat so that the supplementary support of the muscles is lost and the weight is carried entirely on the ischial tuberosities, and at the same time the tissues are drawn very thin over these bones and, being pinched between bone and board, make the seat feel hard. To avoid the pinching it is only necessary, however, to lower the knees by moving the feet forward or back along the floor until the weight is shifted along the thighs as may be desired. The same purpose may be accomplished by the slope or the form of the seat. There is no hygienic reason why hips or knees should be bent precisely at right angles. An extremely low seat, as in a steamer chair,

requiring the feet to be so extended that they do not rest squarely on the floor or the knees and hips to bend at a very sharp angle, involves difficulties of poise of the upper body. Otherwise there appears to be no hygienic difficulty involved in a low seat and no discomfort unless the seat is so flat as to feel hard because of the narrow line of pressure on the ischials. Space for the knees is a problem of desk-height or construction and will be considered in that connection.

Rule for seat-height. We therefore have the following very simple and important principle for determining the correct seat-height for a pupil: The seat must not be high enough to cause *any* pressure under the thighs at or near its front edge when the feet are resting squarely on the floor. There is little if any objection to its being as much as two or three inches lower than this, provided there is space for the pupil to move his feet freely.

Seat-height measure. In the measuring apparatus used in our study a smooth sliding strip is provided on the front edge of the seat. By moving this strip one can tell very readily the degree of pressure from the seat against the legs behind the knees. The footboard is raised until it is assured that there is contact between this strip and the leg at this point but no pressure. The recorded seat-height for each individual is the vertical distance between the footboard and the top of this strip, the knees being bent at right angles and the measure being taken close behind them. This is therefore the *maximum* seat-height measure. At this measured height the pupil cannot move his feet forward without causing pressure under the knees. The measure is taken with pupils in the clothing ordinarily worn in the classroom, including the high heels usually worn by the older girls. The best seat-

height for each individual would probably be an inch or more lower than the recorded measure, varying with the form and slope of the seat; but as this would not be an anatomical measure, it should be used in applying rather than in securing data.

Earlier related studies. The most extensive American study of seat-heights is that by Dr. William A. Stecher, who measured 5678 school children in Philadelphia.[1] To find the seat-height he seated the pupil on a flat-top table, held a book under the sole of the foot, and measured from the top of the book to the top of the table. It is obvious that by this method the weight of the legs and feet was carried by pressure from the edge of the table under the knees, and measures so taken are necessarily too great. Dr. Stecher also found the "desk-height" by taking the distance from the book, as above, "to the underside of the horizontal forearm, the upper arm being held close to the side of the body." He says, "This gave the greatest height of the seat and the lowest height of the desk." No other anatomical measures were taken by which his results can be used for comparison at this point of our study, but his data will be presented later in connection with the grade distribution of seat-heights.

A recent French writer, Paul Godin,[2] emphasizes the importance of low seats and recommends that the seat-height be determined from the height of the anterior tubercle of the tibia, which is felt exteriorly just below the knee joint on the outer side of the leg. No anatomical reasons are given to justify this standard, and it does not take into consideration the large factor of variability arising from the amount of flesh under the thigh. If the measure is correct for a slim, hard-muscled boy, it is considerably too high for a plump girl having the same measure by this standard.

A common direct method of measuring is that which makes use of a scale consisting of a yardstick with a sliding arm. The pupil

[1] *American Physical Education Review* (1911), Vol. XVI, pp. 453–458.

[2] "Growth during School Age and its Application to Education," Part II, chap. iv. Richard G. Badger, Boston, 1920.

is seated, and the sliding arm is placed under the leg close behind the knee, the height from the floor being read as the seat-height. This measure is affected by the height of the seat occupied when the pupil is measured, by the position of the clothing, and by a considerable subjective factor in determining when the sliding arm is pressing correctly under the leg. It is, however, more reliable than other methods of measuring the lower leg which have been used, such as measuring from heel to knee joint while the pupil is standing with the leg bent at the knee.

Ratio of seat-height to standing-height. A surprisingly large proportion of the studies in seating have been confined to measuring the stature of the pupils standing and assuming on slight and unexplained grounds a fixed ratio between this measure and the correct seat-height. The ease with which the stature can be measured is apparently the explanation of the prevalence of this method. This ratio will have our first consideration.

A commonly quoted and accepted rule of apparently German origin is that the seat-height should be approximately two sevenths (.2857) of the standing-height (see, for example, F. B. Dresslar, "School Hygiene," p. 91).

Numerous studies have been made in France, Germany, and Austria and are reported in considerable detail by Eulenberg-Bach ("Schulgesundheitslehre," Vol. I, pp. 238 ff.), by Burgerstein and Netolitsky ("Handbuch der Schulhygiene" (1895), pp. 55–59), by Mery and Génévrier ("Hygiène Scolaire," 1914), by Dufestel ("Hygiène Scolaire," 1914), and elsewhere. None of these give the precise method of measuring the seat-height except that it is "the height of the leg taken under the knee, the child being seated at right angles and the feet squarely on the floor" (Dufestel, chap. v). For purposes of comparison we present figures from the tables of Cardot, based on four thousand children of Paris (from Dufestel), and the Vienna seating regulations, which have also been largely used in Germany (from Burgerstein and Netolitsky).

FROM CARDOT

Height of pupil in centimeters . . .	100–110	110–120	120–135	135–150	150 up
Seat-height in centimeters	28	31	35	40	46

FROM VIENNA

Height of pupil in centimeters	102–117	118–125	126–134	135–144	145–154	155–164	165–174
Seat-height in centimeters .	31	32	34	36	40	42	45

Using the medium-pupil height in each case, we find that according to Cardot the ratios of seat-height to pupil-height are, respectively, .267, .269, .275, .281, and .307 (for 150 centimeters only). Similarly, the Vienna ratios are, respectively, .283, .263, .262, .258, .268, .263, .266.

Dr. F. W. Smedley, Director of Child Study, Chicago, in his report of 1900–1901 to the Board of Education (see also Report of the United States Commissioner of Education (1902), pp. 1094–1138), sets up a table of maximum and minimum statures which can be accommodated in each height of seat. In describing his procedure he states that "different children were placed in each desk until there was determined with reference to each desk the stature of the shortest pupil and the stature of the tallest who could be properly accommodated by that desk." The precise criteria of "proper accommodation" are not given. The results were as follows:

Desk Number	Height of Seat	Maximum Stature accommodated	Minimum Stature accommodated	Ratios	
6	12 in. (30.5 cm.)	127 cm.	113 cm.	.240	.270
5	13 in. (33.0 cm.)	138 cm.	119 cm.	.240	.277
4	14 in. (35.6 cm.)	150 cm.	127 cm.	.237	.280
3	15 in. (38.1 cm.)	162 cm.	137 cm.	.235	.278
2	16 in. (40.6 cm.)	174 cm.	147 cm.	.233	.276
1	17 in. (43.2 cm.)	186 cm.	155 cm.	.232	.279

The most significant point in this report for our purpose is that the same seat can "properly accommodate" pupils differing

in stature by 14 centimeters ($5\frac{1}{2}$ inches) to as much as 31 centimeters (12 inches), or with ratio of seat-height to stature varying from .232 to .280.

Ratio determined by measurement. Table IX shows the distribution of seat-height and standing-height of 3182 pupils as measured by our method and apparatus previously described. The correlation of these two measures was found to be .94. The true mean standing-height for this group is 58.048 inches and the true mean seat-height is 14.523 inches, which gives a ratio of means of .2501, or almost precisely one fourth. Individual ratios vary in a few extreme cases from .19 to .30; that is to say, for the average pupil the seat-height is just one fourth of the standing-height, though for individuals it may vary from two tenths to three tenths.

Dividing the table into seven parts, each including five one-inch intervals of standing-height (the three lowest intervals being included with the 41–45-inch group to avoid an unreliably small group), we note the following interesting series of ratios:

Standing-Height		Seat-Height	Ratio	Number of Cases
Intervals	Mean	Mean		
Inches	*Inches*	*Inches*		
38–45	43.618	10.518	.241	292
46–50	48.324	11.863	.245	471
51–55	53.210	13.286	.250	394
56–60	58.615	14.768	.251	530
61–65	64.328	15.910	.247	1013
66–70	67.775	17.199	.254	427
71–75	73.339	18.739	.255	55

It appears that the ratio increases with marked regularity as the stature increases; that is, the average pupil less than 46 inches in height has a seat-height .241 of his

TABLE IX. CORRELATION OF STANDING-HEIGHT AND SEAT-HEIGHT OF 3182 PUPILS OF ALL SCHOOL GRADES

NOTE. Add .375 to head of each column and line for true mean interval value as explained on page 120. Read 9.375 inches, etc.; 40.375 inches, etc.

Standing-Height in Inches	Seat-Height in Inches												Total
	9	10	11	12	13	14	15	16	17	18	19	20	
38 . . .	1	2	1										4
39 . . .	1	2	1										4
40 . . .	5	5	2										12
41 . . .	11	8	2	1									22
42 . . .	14	22	2										38
43 . . .	11	43	15										69
44 . . .	2	43	16										61
45 . . .	1	35	45	1									82
46 . . .		20	70	8									98
47 . . .		8	56	27									91
48 . . .		1	57	51									109
49 . . .			16	66	1								83
50 . . .			4	70	14	1	1						90
51 . . .			4	62	35								101
52 . . .				29	42	2	2						75
53 . . .		1	1	15	51	9	3						80
54 . . .				1	45	18							64
55 . . .				1	32	36	5						74
56 . . .				2	18	48	4						72
57 . . .					13	70	27						110
58 . . .					8	60	37	1					106
59 . . .					3	26	70	4					103
60 . . .				1	5	36	81	16					139
61 . . .					3	25	114	42					184
62 . . .					1	21	106	87	5				220
63 . . .				1	1	12	98	112	9	1			234
64 . . .					1	7	64	102	35	1			210
65 . . .						3	24	97	41				165
66 . . .					1	1	9	71	49	8			139
67 . . .							5	40	60	15			120
68 . . .						1	1	10	40	16			68
69 . . .							1	2	29	22	4		58
70 . . .								1	19	22			42
71 . . .									1	20	5		26
72 . . .										9	5	1	15
73 . . .										4	2		6
74 . . .								1		1	2	2	6
75 . . .											1	1	2
Totals .	46	190	292	336	274	376	652	586	288	119	19	4	3182

Mean seat-height, 14.523 inches; mean standing-height, 58.048 inches; ratio, .2501.

stature, and the average pupil of more than 71 inches in height has a seat-height of .255 of his stature.

Sex differences in seat-height ratio. Table X, on page 131, shows the distribution by seat-height and standing-height of 1507 boys included in Table IX, on page 129. The true mean standing-height of this group is 58.473 inches and the true mean seat-height is 14.749 inches, which gives a ratio of .252. Likewise, Table XI, on page 132, shows the same distributions for 1445 girls having a true mean standing-height of 57.761 and true mean seat-height of 14.378, which gives a ratio of .249. This indicates, as might be expected from the characteristic difference of flesh conditions, that the average girl has a slightly lower seat-height than the average boy *of the same stature*. That is, the rounder and softer limbs of the girls require lower seats for the same bone length than do the harder and firmer flesh of the boys. This difference, however, would presumably be quite uncertain and changing during the early adolescent period of the grammar grades when, as is well known, girls outgrow the boys for two or three years because of their earlier maturity. The tabulations as made do not permit of a sex comparison based directly upon age or grade advancement, but dividing the two tables arbitrarily according to stature an interesting comparison is possible.

The mean stature of 706 boys in Table X whose standing-height is more than 60 inches is 65.935 inches and their mean seat-height is 16.894 inches, which gives a ratio of .256. The mean stature of 739 girls of Table XI whose standing-height is more than 60 inches is 63.903 inches and their mean seat-height is 15.872 inches, which gives a ratio of .248. That is, the ratio for larger boys is greater than for all boys, and the ratio for larger girls is

Table X. Correlation of Standing-Height and Seat-Height of 1507 Boys of All School Grades

Note. Add .375 to head of each column and line as in Table IX.

Standing-Height in Inches	Seat-Height in Inches												Totals
	9	10	11	12	13	14	15	16	17	18	19	20	
38 . . .		1	1										2
39 . . .		1											1
40 . . .	3	2											5
41 . . .	3	2	1	1									7
42 . . .	5	11	2										18
43 . . .	6	16	3										25
44 . . .	2	27	8										37
45 . . .		19	20										39
46 . . .		12	38	2									52
47 . . .		6	29	11									46
48 . . .		1	33	23									57
49 . . .			7	30									37
50 . . .			1	30	2	1							34
51 . . .			2	26	11								39
52 . . .				11	22		1						34
53 . . .		1		9	19	4	2						35
54 . . .					32	10							42
55 . . .				1	18	15	1						35
56 . . .				1	14	26	3		1				45
57 . . .					10	38	9						57
58 . . .					2	27	19	1					49
59 . . .					3	11	27	2					43
60 . . .				1		7	45	9					62
61 . . .						5	36	23					64
62 . . .						4	38	36	3				81
63 . . .						1	19	49	4	1			74
64 . . .							5	45	22	1			73
65 . . .							4	39	26				69
66 . . .							2	37	28	8			75
67 . . .								18	50	15			83
68 . . .								8	33	15			56
69 . . .								1	21	21	3		46
70 . . .								1	15	18			34
71 . . .										20	5		25
72 . . .										9	4	1	14
73 . . .										4	2		6
74 . . .										1	1	2	4
75 . . .											1	1	2
Totals	19	99	145	146	133	149	211	269	203	113	16	4	1507

Mean seat-height, 14.749 inches; mean standing-height, 58.473 inches; ratio, .252.

TABLE XI. CORRELATION OF STANDING-HEIGHT AND SEAT-HEIGHT OF 1445 GIRLS OF ALL SCHOOL GRADES

NOTE. Add .375 to head of each column and line as in Table IX.

STANDING-HEIGHT IN INCHES	SEAT-HEIGHT IN INCHES												TOTALS
	9	10	11	12	13	14	15	16	17	18	19	20	
38	1	1											2
39	1	1	1										3
40	2	3	1										6
41	8	5	1										14
42	9	11											20
43	5	27	12										44
44		16	8										24
45		13	24	1									38
46		7	29	6									42
47		1	22	16									39
48			14	27									41
49			4	32	1								37
50			1	31	12		1						45
51				24	23								47
52				7	16	2	1						26
53			1	3	20	5	1						30
54					7	8							15
55					8	19	4						31
56						16	1						17
57					2	21	12						35
58					4	22	15						41
59						12	30	2					44
60					5	22	31	7					65
61					2	20	75	18					115
62					1	16	66	45	2				130
63				1	1	11	76	59	5				153
64					1	6	59	56	13				135
65						2	20	56	13				91
66					1	1	7	32	17				58
67							5	24	8				37
68						1	1	2	6	1			11
69							1	1	4	1			7
70									2				2
Totals .	26	85	118	148	104	184	406	302	70	2			1445

Mean seat-height, 14.378 inches; mean standing-height, 57.761 inches; ratio, .249.

less than for all girls. Applying these ratios, for example, to 64-inch average individuals, the seat-height of the boy would be 16.384 inches and that of the girl would be but 15.872 inches, a difference of more than half an inch. But it is to be remembered that pupils were measured in the clothing usually worn in school, and this, among the larger girls, usually includes heels from half an inch to one inch higher than those worn by boys, so that the actual anatomical difference would be materially greater than shown by these figures.

Ratio as a guide for seating. The ratio of a group average, however, tells us nothing about the ratio of seat-height to stature for a given individual, nor will the standard deviation indicate the seat-height which will be favorable to correct posture. As a more direct means of determining the reliability of the .25 ratio as a rule for the assigning of seats to children, the following method is adopted. In Table IX there is underscored in each seat-height column the number opposite the standing-height which is nearest four times the seat-height (for example, four times 15.375 inches (seat-height) is 61.5 inches), and in this seat-height column the number 114, which stands opposite standing-height 61.375, is underscored; or, in other words, these 114 individuals are the only ones in this column having the average ratio of .25 between seat-height and standing-height. By adding together the underscored numbers, it is found that 484 individuals (15.2 per cent of the 3182) are correctly seated (within one eighth of an inch) on the .25 ratio. By adding together all the numbers in the several columns *above* the underscored numbers, we find that 1312 (41.2 per cent) can use a seat-height higher than 25 per cent of the standing-height. Of these, 1140 (35 per cent) have a measured seat-height within $1\frac{1}{4}$ inches more than the .25 ratio, and all but six scattered cases are within 2 inches of it. On the assumption already made that a seat-height an inch or two lower than the measured height is not objectionable, all these 1796 (56.4 per cent) may be regarded

as properly seated on the .25 ratio. Adding, now, the numbers *below* those underscored, it is found that 1386 (43.6 per cent) would have seats too high on this basis. The 1305 pupils enumerated in the five numbers next below each underscored number would be correctly seated (within .22 inch) in seats an inch lower than the .25 ratio. The 62 individuals listed in the two numbers in each column next below these would be correctly seated (within .22 inch) in seats $1\frac{1}{2}$ inches lower than the .25 ratio. This leaves 19 (0.6 per cent) who require seats yet lower.

In summary, 56.4 per cent are correctly seated in seats having a height of 25 per cent of standing-height, 97.5 per cent at this height or an inch lower, and 99.4 per cent in seats of this height or within $1\frac{1}{2}$ inches lower.

Practical use of the standing-height ratio. If the standing-height is to be used at all for assigning or adjusting seats, the .25 ratio is fairly safe for slightly more than one half; the remainder, including the short-limbed and the fleshy individuals, will require seats an inch or two lower. There is no way of knowing which individuals belong to the latter group except by making sure, after they are seated, that there is no pressure from the seat under the knees. Since pupils are distributed by grades and not by heights, and since the stature measure is but a rough approximation of seat-height, it will be found that the seat-height assortment by grades, which is presented in the next chapter, is a more practical means of selecting and assigning seats for grade rooms.

CHAPTER XII

ASSORTMENTS OF SEAT SIZES FOR THE SEVERAL GRADES

Earlier studies. The most acute seating problem for the administrator who is selecting and installing school furniture is the distribution of seat sizes to the various grade rooms. More statistical material has been published in this connection than in that of any other school seating question. In fact, practically all extensive measuring done hitherto has had this as its objective. Most French and German works on school hygiene, so far as they deal with the seating problem, present extensive tabulations drawn from many sources attempting to establish authoritative schedules of seat sizes, and many governmental regulations on the subject have been issued in Europe.

About 1896 Dr. W. T. Porter of Harvard made extensive anthropometric measures of school children of Boston and St. Louis.[1] These studies tabulated standing-height in relation to age and weight and did not include an investigation of seat-height. They are mentioned here only because they have since been used to set up standards for seat distribution by arbitrarily assuming a relation between age and grade and between standing-height and seat-height.

[1] "Percentile Charts of the Height and Weight of Boston School Children," *Boston Medical and Surgical Journal*, Vol. CLXXXVIII, pp. 639–644; "Anthropometric Measurements in School," *Educational Review*, Vol. XI (1896), pp. 126–133; "Growth of St. Louis School Children," Transactions of the St. Louis Academy of Science, Vol. VI, pp. 263–380.

Smedley, in his Chicago studies previously cited (Report of the United States Commissioner of Education (1902), pp. 1094–1138), surveyed the actual seating in the grades of the Chicago schools and compared the results with the standards of seat-height as related to stature limits which he had developed and which are quoted above in Chapter XI. His tabulation is as follows:

Grade	Desk Number	Percentage of Pupils below Minimum	Percentage of Pupils within Limits	Percentage of Pupils above Maximum
1	6	15.87	72.42	1.80
2	5	19.97	77.50	2.53
3	5	3.59	82.91	13.59
4	4	8.75	87.04	4.21
5	4	3.07	81.55	15.36
6	3	11.06	83.53	5.41
7	3	4.18	78.07	17.75
8	2	10.75	86.56	2.69
High school	1	15.87	83.78	0.35

On the basis of these findings Smedley recommended a combination of adjustable and nonadjustable seats for the several grades as follows:

Grade	Percentage Nonadjustable	Desk Size	Percentage Adjustable	Size
2	75	5	25	C1
3	80	5	20	
4	85	4	15	B1
5	80	4	20	
6	80	3	20	
7	75	3	25	
8	85	2	15	A1
High school	85	1	15	

In view of the fact that 26 per cent of the first-grade pupils were too small for any desk then purchased by the committee, Smedley recommended that bids be secured on a seat adjustable from 10 to 12 inches, and that the first grade be provided with 30 per cent of these and 70 per cent of No. 6 desks.

Stecher, on the basis of the measurements to which we have previously referred, recommended for the schools of Philadelphia assortments of desk sizes for each half-grade as follows:

Desk Number	Seat-Height	Desk-Height	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b
	Inches	*Inches*	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
6	10	18	31	14														
5	11	19	47	40	33	20												
4	12	21	12	33	40	44	41	26	22	21								
3	14	23			14	18	37	48	47	46	40	38	33	27	21	15	12	8
2	16	25					8	13	16	25	42	48	45	51	54	51	57	51
1	18	27									7	7	11	14	16	20	16	27
Adjustable . . .			10	13	13	18	14	13	15	8	11	7	11	8	9	10	15	14

For convenience of comparison with our own data presented in this chapter, we may combine Stecher's figures for half-grades into grades, as follows:

Desk Number	6	5	4	3	2	1	Adjustable
Seat-Height in Inches	10	11	12	14	16	18	
Grade	%	%	%	%	%	%	%
I	22.5	43.5	22.5				11.5
II		26.5	42.0	16.0			15.5
III			33.5	42.5	10.5		13.5
IV			21.5	46.5	20.5		11.5
V				39.0	45.0	7.0	9.0
VI				30.0	48.0	12.5	9.5
VII				18.0	52.5	18.0	9.5
VIII				10.0	54.0	22.5	14.5

Depending as they do on the adjustment of the adjustables and the distribution of pupils whose seat-height measures 13, 15, and 17 inches, these figures do not differ from our own as much as would be expected from the difference in measuring-technique previously mentioned and the probability that Philadelphia schools were not as closely graded in 1911 as were the schools included in our investigations in 1924–1925.

TABLE XII. DISTRIBUTION OF STANDING-HEIGHT OF 1500 PUPILS BY SCHOOL GRADES

STANDING-HEIGHT IN INCHES	GRADES												TOTAL
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
40		1											1
41	3												3
42	3												3
43	10												10
44	10												10
45	19	2	1										22
46	16	4	1	1									22
47	15	6	4	2									27
48	15	13	8	4									40
49	8	8	16	6									38
50	1	12	20	14	3								50
51	1	13	27	26	8	2							77
52		6	10	32	7	2	1	1					59
53	1	7	18	19	16	6	1						68
54		2	8	20	17	10							57
55		1	4	8	26	17					1		57
56		1	5	9	10	11	2	1	2				41
57		1	1	13	14	25	6	3	1				64
58			1	7	9	18	3	2	2		1		43
59				2	6	20	5	4	2		1		40
60				2	5	14	5	10	7	4	2	1	50
61				2		7	1	7	14	7	3	1	42
62					3	5	2	10	29	14	13	5	81
63						4	3	8	30	16	13	8	82
64						3	1	5	35	24	8	21	97
65						1	1	4	30	27	16	8	87
66						1		6	21	24	9	10	71
67								1	18	27	15	12	73
68									4	15	20	7	46
69								1	9	17	13	9	49
70									5	14	10	9	38
71								1	2	7	8	7	25
72									1	4	5	3	13
73										1	2	3	6
74											3	3	6
75										1		1	2
Totals . . .	102	77	124	167	124	146	31	64	212	202	143	108	1500

Grade distribution of standing-height. Table XII shows the distribution of the standing-height according to school grade of the first 1500 pupils measured in our study. By reading the columns down it is seen that the table shows

a fairly normal distribution of pupil stature through a range of 12 to 18 inches in each grade. Children of the mean stature are found in every grade from the fourth to the twelfth, and other heights are similarly distributed. An increase in the number of cases would smooth the distribution and, in some cases, slightly increase the range.

Grade distribution of seat-height. Table XIII shows the distribution of 3615 pupils according to grade and seat-height. There is a normal distribution of seat-height through a range of about 6 inches in each primary and about 8 inches in each high-school grade. This range is greater than would be anticipated from the grade distribution of standing-height if the latter were a reliable basis of prediction on the .25 ratio, since a variation of 8 inches in seat-height would then indicate a variation of 32 inches in stature. It will be noted that 13-inch and 14-inch seats are indicated in every grade from the first to the twelfth.

TABLE XIII. DISTRIBUTION OF SEAT-HEIGHT ACCORDING TO SCHOOL GRADES OF 3615 PUPILS

NOTE. Add .375 to head of each column for true mean of interval.

School Grade	Seat-Height in Inches												Totals
	9	10	11	12	13	14	15	16	17	18	19	20	
Kindergarten	58	116	68	5									247
I	12	143	243	82	5	1							486
II		24	106	178	35	6	1						350
III		4	33	103	72	19	3	1					235
IV			4	47	70	33	12	1					167
V.				16	52	31	21	4					124
VI		1		3	18	64	44	14	2				146
VII				2	27	120	187	112	20	2			470
VIII				2	12	56	188	166	53	7	1		485
IX				1	6	30	118	166	102	26	1		450
X					2	10	37	57	60	32	6		204
XI					5	8	26	38	29	28	7	2	143
XII					1	7	20	27	23	24	4	2	108
Totals . .	70	288	454	439	305	385	657	586	289	119	19	4	3615

The number of rooms of each grade covered by this study varies from four to eleven, owing to various circumstances under which the measuring was done. This accounts for the uneven distribution of the grade totals, especially of Grades IV–VI, and prevents any massing or averaging of data of seat sizes for a school system as a whole. The distribution is sufficiently regular, however, to indicate that a larger or more evenly distributed body of data would not change the results noticeably for schools of the same general type, nor affect any of the conclusions presented. It is probable that schools in which the attendance is predominantly of races of relatively small stature would give averages lower than those in which attendance is mainly of the tall north-European stock. There is some indication that favorable community environment gives a larger average stature as well as seat-height, but how far this is distinguishable from the racial factor cannot be determined from the data now available. On the contrary, unfavorable social environment makes for a greater amount of retardation, and this tends to raise the grade averages of seat-height and stature. Only the measurement of all pupils of a large number of rooms of each grade, with a careful analysis of all racial, social, and educational factors determining the enrollment of pupils, can throw any valuable light on these problems. It is doubtful if such investigation would have any practical value, since these factors are constantly changing, particularly those involved in acceleration or retardation, whereas an equipment of school desks lasts long enough for a complete change of social or industrial environment to take place in a modern American city.

The chance and unpredictable variations of size among the pupils who happen to constitute a given class at a given time will amount to more than any theoretical probabilities. For this reason the selection of permanent equipment on the basis of the measurement of pupils who are to use it first is not as reliable as selection on the basis

of measurement of widely distributed classroom groups. Measures taken in several typical cities, as ours have been, are more likely to be representative of the classes which will occupy a given room for the next ten or twenty-five years than the most careful measurement of the class now in the room. For these reasons Tables XIV and XVII are probably a safer guide for permanent size assortments than any local measures, unless the latter be equally accurate and more extensive and representative of the system as a whole.

TABLE XIV. PERCENTAGE DISTRIBUTION OF SEAT-HEIGHT ACCORDING TO SCHOOL GRADES, BEING THE DATA OF TABLE XIII EXPRESSED IN PER CENTS TO THE NEAREST UNIT

NOTE. Add .375 to head of each column for true mean of interval.

School Grade	Seat-Height in Inches												Totals
	9	10	11	12	13	14	15	16	17	18	19	20	
Kindergarten	23	47	28	2									100
I	3	29	50	17	1								100
II		7	30	51	10	2							100
III		2	14	44	30	8	2						100
IV			2	28	43	19	7	1					100
V				13	42	25	17	3					100
VI				3	12	44	30	10	1				100
VII					6	26	40	24	4				100
VIII					3	11	39	34	11	2			100
IX					2	7	26	37	22	6			100
X					1	5	18	28	29	16	3		100
XI					3	6	18	27	20	20	5	1	100
XII					1	6	19	25	21	22	4	2	100

Distribution among the grades of standard seat sizes. Since most seats are not made in sizes differing from each other in one-inch intervals, it is desirable to interpret the data of Tables XIII and XIV into standard sizes of non-adjustable seats. On the following page are given the

seat-height measures of the several sizes according to the manufacturer's standard which is most widely in use on nonadjustable desks at the present time, with the seat-height measure of pupils for which each is best suited.

Size Number	Seat-Height of Desk in Inches	Seat-Height of Pupils in Inches
6	11	12 (or less)
5	$12\frac{1}{4}$	$12\frac{1}{4}$–$13\frac{1}{4}$ (inclusive)
4	$13\frac{1}{2}$	$13\frac{1}{2}$–$14\frac{1}{2}$ (inclusive)
3	$14\frac{3}{4}$	$14\frac{3}{4}$–$15\frac{3}{4}$ (inclusive)
2	16	16 –17 (inclusive)
1	$17\frac{1}{4}$	Over 17

Redistributing the grade pupils of Table XIII (Kindergarten omitted) precisely according to seat sizes as defined above (considering fractions) we have the following:

TABLE XV. DISTRIBUTION OF STANDARD SEAT SIZES ACCORDING TO SCHOOL GRADES FOR 3368 PUPILS

Grade	Seat-Size Number						Total
	6[1]	5	4	3	2	1	
I	418	64	4				486
II	174	152	21	3			350
III	63	113	51	7	1		235
IV	16	70	60	20	1		167
V	4	38	50	28	4		124
VI	2	11	57	60	15	1	146
VII		15	104	217	117	17	470
VIII		8	48	202	179	48	485
IX		4	25	126	191	104	450
X		1	9	39	72	83	204
XI		2	9	28	45	59	143
XII			6	22	33	47	108

[1] Or smaller.

Reducing this table to percentages (using the nearest integers) we have the following:

TABLE XVI. PERCENTAGE DISTRIBUTION OF STANDARD SEAT SIZES FOR EACH GRADE, BEING THE DATA OF TABLE XV REDUCED TO PER CENTS

GRADE	SEAT-SIZE NUMBER					
	6[1]	5	4	3	2	1
I	86	13	1			
II	50	43	6	1		
III	27	48	22	3		
IV	10	42	36	12		
V	3	31	40	23	3	
VI	1	8	39	41	10	1
VII		3	22	46	25	4
VIII		2	10	41	37	10
IX		1	5	28	42	24
X			5	19	35	41
XI		1	6	20	31	42
XII			5	20	31	44

[1] Or smaller.

It is impracticable to use these odd per cents in selecting seats for a classroom. By reducing them to round numbers which are applicable to classroom seating and limiting the number of sizes to three in any room, we derive the following simple table of sizes.

TABLE XVII. PRACTICABLE DISTRIBUTION OF STANDARD SEAT SIZES FOR THE SEVERAL GRADES

GRADE	SEAT-SIZE NUMBER					
	6	5	4	3	2	1
	Per Cent	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
I	90	10				
II	50	50				
III	25	50	25			
IV		50	40	10		
V		35	40	25		
VI		10	40	50		
VII			25	50	25	
VIII			10	40	50	
High school				25	40	35

Table XVII is probably as reliable a guide for equipping a grade room with nonadjustable desks as can be made from any obtainable data. The variable factors are unpredictable for more than a few years of the life of such equipment.

Seating survey of special schools. As an illustration of the fact that school-seating is almost invariably too high, and as an illustration of a method of presenting data showing this and other related facts, the following tabulation is submitted. The school in which these measures were taken is one of the most progressive in a leading Middle West city. It is designated and conducted as an experimental school, although in every respect part of the city system. All the seating in this school is movable, including several types of chair desks, and certain rooms are equipped with tables and chairs.

Each table shows the seating for a single room, the room number and grade being indicated. The numbers at the tops of the columns indicate the heights of the seats actually in use by the children enumerated in the columns. The numbers at the left are the seat-heights of the children as measured by our apparatus. The rules in the columns show the maximum height limits of correct seating. The numbers below these lines indicate the number of children seated correctly or lower than necessary; numbers above these lines indicate the children in seats too high, and the seats are too high by as many half-inches as the numbers are spaces above the lines.

Of the 514 children here reported, 38, or 7.4 per cent, are correctly seated according to our measures; 22 (4.2 per cent) are in seats slightly but not objectionably low; *454 (88.4 per cent) are in seats too high,* 127 of them having seats two inches or more too high and 29 having seats three inches or more too high.

TABLE XVIII. GRADE I B, ROOM 101

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES		TOTAL
	12–12½	13–13½	
9–9¼ . . .		1	1
9½–9¾ . . .		1	1
10–10¼ . . .	2	5	7
10½–10¾ . . .	4	2	6
11–11¼ . . .	5	5	10
11½–11¾ . . .		6	6
12–12¼ . . .	3	2	5
12½–12¾ . . .			
Totals . .	14	22	36

TABLE XIX. GRADE I B, ROOM 102

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES		TOTAL
	12–12½	13–13½	
9–9¼ . . .			
9½–9¾ . . .		1	1
10–10¼ . . .	1	4	5
10½–10¾ . . .	2	5	7
11–11¼ . . .	5	5	10
11½–11¾ . . .	1	6	7
12–12¼ . . .	2	5	7
12½–12¾ . . .		1	1
Totals . .	11	27	38

TABLE XX. GRADE III B, ROOM 104

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES		TOTAL
	14½	15½	
11½–11¾ . . .	4		4
12–12¼ . . .	6		6
12½–12¾ . . .	10	2	12
13–13¼ . . .	7		7
13½–13¾ . . .	7	1	8
14–14¼ . . .	1	1	2
14½–14¾ . . .	1		1
Totals . .	36	4	40

TABLE XXI. GRADE III A, ROOM 105

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES				TOTAL
	12	13½	14	15½	
11½–11¾ . .		1	1		2
12–12¼ . .	1		6	1	8
12½–12¾ . .			7	1	8
13–13¼ . .			6	3	9
13½–13¾ . .			7	1	8
14–14¼ . .			3		3
14½–14¾ . .				1	1
Totals .	1	1	30	7	39

TABLE XXII. GRADE IV B, ROOM 108

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES		TOTAL
	14½	15–15½	
11½–11¾ . . .	2	1	3
12–12¼ . . .	1	3	4
12½–12¾ . . .	5	2	7
13–13¼ . . .	1	11	12
13½–13¾ . . .		1	1
14–14¼ . . .	4	4	8
14½–14¾ . . .	1		1
15–15¼ . . .		1	1
Totals . .	14	23	37

TABLE XXIII. GRADE IV B, ROOM 109

SEAT-HEIGHT IN INCHES	HEIGHT OF SEAT IN USE IN INCHES				TOTAL
	14	14¾	15	15¾	
12–12¼ . .	1		2		3
12½–12¾ . .	5		1	1	7
13–13¼ . .	1	2	2	1	6
13½–13¾ . .	3	1	1	2	7
14–14¼ . .		1			1
14½–14¾ . .			2		2
15–15¼ . .	1		1		2
15½–16 . .	1				1
Totals .	12	4	9	4	29

TABLE XXIV. GRADE II A, ROOM 1

Seat-Height in Inches	Height of Seat in Use in Inches					Total
	12	12¾	13	14½	15½	
10 –10¼		1				1
10½–10¾			1			1
11 –11¼	2	2	2		1	7
11½–11¾	1	3	5	1		10
12 –12¼	1	3	5	2		11
12½–12¾		2	3	1		6
13 –13¼	1		2		1	4
13½–13¾			1			1
14 –14¼					1	1
14½–14¾						
Totals	5	11	19	4	3	42

TABLE XXV. GRADE VI A, ROOM 202

Seat-Height in Inches	Height of Seat in Use in Inches				Total
	14	15¼	16¼	17½	
11½–11¾		1			1
12 –12¼		1			1
12½–12¾	1	2			3
13 –13¼	2	5			7
13½–13¾	3	5			8
14 –14¼	1	3		2	6
14½–14¾		4	1		5
15 –15¼		3		1	4
15½–15¾					0
16 –16¼			1		1
Totals	7	24	2	3	36

TABLE XXVI. GRADE VI A, ROOM 201

Seat-Height in Inches	Height of Seat in Use in Inches				Total
	15	16	16½	17	
10½–10¾					
11 –11¼					
11½–11¾					
12 –12¼					
12½–12¾					
13 –13¼					
13½–13¾	1		1	3	5
14 –14¼	1		2	2	5
14½–14¾			1	2	3
15 –15¼			1	4	5
15½–15¾		1		2	3
16 –16¼		1	1		2
16½–16¾		1			1
17 –17¼				1	1
17½–17¾					
18 –18¼				1	1
Totals	2	3	6	15	26

TABLE XXVII. GRADE VI A, ROOM 205

Seat-Height in Inches	Height of Seat in Use in Inches						Total
	12	13	14½	15½	16½	17½	
10½–10¾	1						1
11 –11¼	1		1				2
11½–11¾	1						1
12 –12¼		3	2				5
12½–12¾	1		5	1			7
13 –13¼			1	1			2
13½–13¾			3	2	1		6
14 –14¼			2	1			3
14½–14¾					1		1
15 –15¼					1		1
15½–15¾							
16 –16¼						1	1
16½–16¾							
17 –17¼							
Totals	4	3	14	5	3	1	30

Table XXVIII. Grade VI B, Room 208

Seat-Height in Inches	Height of Seat in Inches in Use		Total
	15¾	17¾	
12½–12¾ . . .	1	1	2
13 –13¼ . . .		1	1
13½–13¾ . . .		3	3
14 –14¼ . . .	2	5	7
14½–14¾ . . .	2	9	11
15 –15¼ . . .	1	4	5
15½–15¾ . . .		3	3
16 –16¼ . . .	1	1	2
16½–16¾ . . .		1	1
17 –17¼ . . .			
Totals . .	7	28	35

Table XXIX. Grade VI B, Room 207

Seat-Height in Inches	Height of Seat in Use in Inches		Total
	16	17¾–18	
12½–12¾ . . .		1	1
13 –13¼ . . .			
13½–13¾ . . .	1	2	3
14 –14¼ . . .	1	6	7
14½–14¾ . . .	1	5	6
15 –15¼ . . .		8	8
15½–15¾ . . .		3	3
16 –16¼ . . .		1	1
16½–16¾ . . .			
17 –17¼ . . .		1	1
17½–17¾ . . .			
Totals . .	3	27	30

Table XXX. Grade V B, Room 203

Seat-Height in Inches	Height of Seat in Use in Inches		Total
	15	16	
12 –12¼ . . .			
12½–12¾ . . .	2		2
13 –13¼ . . .	2		2
13½–13¾ . . .	3	5	8
14 –14¼ . . .		3	3
14½–14¾ . . .		1	1
15 –15¼ . . .		2	2
15½–15¾ . . .		1	1
16 –16¼ . . .		2	2
16½–16¾ . . .			
17 –17¼ . . .			
Totals . .	7	14	21

Table XXXI. Grade V B, Room 206

Seat-Height in Inches	Height of Seat in Use in Inches				Total
	14¼	15¼	16¼	17	
12 –12¼ . .	1	1			2
12½–12¾ . .	2	1			3
13 –13¼ . .	1	5			6
13½–13¾ . .	2	8	1		11
14 –14¼ . .	1	6	2		9
14½–14¾ . .	3		1		4
15 –15¼ . .	1	1	2	1	5
15½–15¾ . .		1		1	2
Totals . .	11	23	6	2	42

TABLE XXXII. GRADE V A, ROOM 204

Seat-Height in Inches	Height of Seat in Use in Inches			Total
	14½	15½	17½	
12 -12¼	1			1
12½-12¾	1			1
13 -13¼	6	1		7
13½-13¾	7	2		9
14 -14¼	3	2		5
14½-14¾	1			1
15 -15¼	3	3	1	7
15½-15¾	2	1		3
16 -16¼			1	1
Totals	24	9	2	35

TABLE XXXIII. SUMMARY OF TABLES XVIII–XXXII. MEASURED SEAT-HEIGHT OF 514 PUPILS OF ONE SCHOOL (15 ROOMS) CORRELATED WITH THE ACTUAL HEIGHT OF THE SEATS IN USE

Seat-Height in Inches	Height of Seats in Use in Inches												Total
	12	12½	13	14	14½	15	15½	16	16½	17	17½	18	
9 - 9¼			1										1
9½- 9¾			2										2
10 -10¼	3	1	9										13
10½-10¾	7		8										15
11 -11¼	13	2	12		1	1							29
11½-11¾	3	3	17	8		2							33
12 -12¼	7	3	15	16	4	8							53
12½-12¾	1	2	4	31	7	10	2				2		59
13 -13¼	1		2	24	3	30	1	1			1		63
13½-13¾			1	29	4	23	4	7	2	3	3	2	78
14 -14¼				13	3	18	3	6	2	4	5	6	60
14½-14¾				6		6	2	5	2	2	14		37
15 -15¼				5		9	1	4	2	7	4	8	40
15½-15¾				3		2		2		3	3	3	16
16 -16¼							1	4	1	1	2	1	10
16½-16¾								1			1		2
17 -17¼										1			1
17½-17¾												1	1
18 -18¼										1			1
Totals	35	11	71	135	22	109	14	30	9	22	35	21	514

A similar study of the seating of the first three grades in a well-organized school in an Eastern city shows 69 per cent of the pupils on seats definitely too high. Old combination desks were in use in this school, and though none of the seats were too low, the bookshelves interfered with the knees of about 2 per cent.

Tendency to oversize seats is general. Informal observation in many schools, which may be verified in a few minutes in almost any school, supports the conclusion that for some unexplained reason school seats are almost always much too high, although there is every reason why they should be lower instead of higher than measure. Although it is indicated by Table XIV that 70 per cent of kindergarten children have a seat-height of 9 or 10 inches and only 2 per cent as high as 12 inches, kindergarten chairs are usually sold in 12-inch and 14-inch heights and are actually offered in 16-inch heights. Dealers report that there is so little demand for 10-inch heights that most of them do not offer or carry them in stock at all. In almost any kindergarten it will be observed that a large proportion of the children cannot touch their heels to the floor when they are sitting back in their chairs. Many of them "have to climb up to sit down and slide down to stand up." The usual seat-height of a No. 6 desk is 11 inches, and 82 per cent of first-grade children require this size or smaller. Yet in many school systems no No. 6 desks are used, No. 5 being regularly used in the first grade. Where chairs are installed instead of school desks for first grades 12-inch and 14-inch chairs are generally used in chance proportions. The same tendency to oversize seating prevails through the grades. High schools are often equipped exclusively with No. 1 desks or 18-inch chairs, although the figures show

that only about 35 per cent of high-school pupils are large enough for the former and but 20 per cent for the latter.

First step in reform. Perhaps the reform most urgently needed in school-seating is a general upward shifting from grade to grade of the seats now in use, filling in at the bottom with suitably sized and proportioned seating and eliminating most of the largest sizes at the top. Even in colleges and universities and in rooms for adult use, 18-inch seating is too high for the large majority. In universities for mature men only, a large proportion will be properly seated at 17 or 18 inches, but even here the majority would probably be as well seated, and a minority much better, at 16 inches.

Women have in most cases reached their full stature in the high-school age, their subsequent development being in the way of increased fleshiness, which demands lower seating. Hence for women's colleges and for co-educational institutions only a small proportion, if any, of the seats should be higher than they should be for high schools. No statistical data for these higher institutions are yet available, but considerable observation and inquiry substantiates the foregoing inference. A large proportion of college women are now unable to rest their feet comfortably on the floor while occupying the class-room seats. It is well to mention here that the standard seat-height of adult-size opera and auditorium seats is 16 inches, and although women frequently complain that these are too high, the objection that they are too low is practically unknown. This, too, in face of the fact that many of these are upholstered, whereas school seats are always hard and unyielding.

Seat assortments for departmental and high schools. In the typical high-school and platoon-school organization

and in departmental instruction in other schools various grades occupy the same rooms in successive periods. No interchanging or adjusting of seats from hour to hour is at all practicable. If the grades using the same seats differ by more than two or three years in development, it cannot be expected that the equipment can be equally suitable for all. A second grade and an eighth grade cannot possibly be correctly seated in the same seats, and conditions of this sort should be avoided in the organization of the school. But three or four grades of a high school, or as many of an intermediate platoon school, are regularly expected to use the same rooms. If one of these groups uses the room for a considerable proportion of the day as a "home room," the requirements of that class should have prior consideration, and the visitors may have to suffer some discomfort. If several classes make use of the room for approximately equal periods, the seating should be adapted so far as practicable to the group of smaller rather than larger physique, in view of the principle of low rather than high seating.

The problem is somewhat different where the "elective system" prevails and no class groups remain constant in their personnel. If certain rooms are used only by classes attended by boys or girls exclusively, the seats should certainly be lower for the girls than for the average or for the boys only. Obviously situations involving so many unknown and changing factors cannot be definitely solved in advance, but it is nevertheless possible to seat pupils with a very large proportion of correctness even in the complexities of departmental organization.

The responsibility rests largely upon the classroom teacher to see that pupils occupy seats which do fit them, as far as possible. This is not a difficult matter if pupils

are carefully taught that each must select in every room a seat in which when he sits erect, with feet squarely on the floor, there is no pressure under the knees. It requires but a few moments at the beginning of the semester, when a newly organized class enters a room, for each pupil to find a seat that meets this standard — so far as the assortment of sizes permits. In a very few moments more the teacher can verify the facts by a hasty observation. A few exchanges between those whose seats are unnecessarily low and those whose seats are not low enough will provide for many of those not properly seated.

Now nearly all the seats in an ideal assortment of sizes for one grade would also be included in an ideal assortment for a grade one or two years above or below. For example, if a room were correctly equipped for a tenth grade, it would probably suit a twelfth grade equally well and would suit all but some 15 per cent of eighth-grade pupils. If there were provided an excess of seats over the actual number required for a standard grade, then, by adding to the tenth-grade assortment some 15 per cent in small sizes, every grade from the eighth to the twelfth would be correctly seated. If one or two extra-large and extra-small seats are added to the grade assortment for every high-school room, any high-school grade would probably be perfectly provided for.

CHAPTER XIII

DEPTH, SLOPE, AND FORM OF THE SEAT

Seat-depth. The depth of the seat (length from front to back) is no less important in posture than is the height. Just as we have found in the matter of height that only seats too high are harmful, so we shall find in reference to depth that only seats too deep are hygienically objectionable. There is no harm in seats that are low and short nor, within reasonable limits, any discomfort. No part of the seat functions for true sitting-support except that under the ischials and the upper half of the thigh muscles. Beyond this no part of the seat area serves any useful sitting-purpose except so far as it provides for desirable change of position and freedom of movement. A long seat is unnecessary to the long-limbed person and is of great disadvantage to the short-limbed. Seats must be made to accommodate either.

We have already explained that seat support under the area just behind the knees (popliteal) does not support body weight; since, as a simple matter of leverage, so far as it carries any weight at all, it merely serves to lift the feet from the floor. Furthermore, any pressure in this area is against the nerves and blood vessels, which causes discomfort and possible serious injury. If, in addition to this, the seat is so deep that any individual using it is prevented by the knee bend from getting full support from the back, especially at the lumbar level, whatever back support there may be is rendered unhygienic, since

one can only lean his shoulders against it and slump when the back muscles relax.

A further advantage of a short seat is that it makes almost impossible such slumped and sprawling postures as that shown in Fig. 23, p. 92.

Measures of seat-depth. The significant measure of seat-depth is not the amount of wood surface, but the length of effective support afforded. This depends on the position of the ischial bones as fixed by the contour of the seat bed or by the back support; that is, how far back in the seat one sits. By comparing Figs. 21 and 22 with Fig. 24 (Chapter VIII) it will be seen that one sits much farther back in the seat shown in the last figure than in either of the others. If these seats were all of the same depth, that in Fig. 24 would extend much farther forward under the knees than either of the others; hence a seat with a back of this design should be three or four inches shorter than the others and would yet be as long in effect. For reasons presented elsewhere the back support should be of the lumbar type shown in Fig. 24, with no part of it preventing the extension of the buttocks back under it as shown. Also, as shown elsewhere, there should be no scoop in the seat nor elevation at the rear of it which will prevent the sitter from sliding back freely until the full back support at the lumbar level is attained. This lumbar back support is therefore the one fixed position with relation to which all measures of seat-depth should be made. It is the only point from which anatomical measures can be made to determine how deep the seat should be. The position of the ischial bones on the seat is used in this study for determining the form of the seat bed, but it cannot be used for the depth of

the seat because their position on the seat cannot be determined except with reference to the back support.

As one sits erect the horizontal distance from the lumbar back support to the angle under the knees is the maximum depth of seat which one can occupy and have full benefit of the back support. This is considerably longer than the seat should actually be, but it is an anatomical measure by which individuals can be compared and from which statistical data can be derived for the purpose of determining the design of seats. This measure was obtained for all pupils measured for this study.

This is the distance indicated as B in Fig. 29 and so recorded and tabulated. The measuring apparatus is so constructed that this distance is automatically registered when the pupil slides as far back in the seat as his knee joints permit, and the back-piece is fitted into his lumbar curve as he sits erect. The possible error arising from the difficulty of securing uniformly erect position was recognized and guarded against by using the greatest care in applying uniformly the standards of erectness frequently stated in previous chapters; namely, pelvis in vertical position (as in Figs. 1, 5, and 24), spine poised and sustaining the body weight, shoulders hanging back and down. Satisfactory erectness was impossible to obtain in some older pupils whose habitual stoop had become practically fixed, nevertheless the measure is the accurate record of the anatomical distance sought. Many very young pupils were unable, under the conditions, actually to sit erect, but the individual measures were close enough for the purpose intended and the average is thoroughly reliable.

The correlation of this B measure with the seat-height measure for 3194 pupils is given in Table XXXIV, and the same correlation for about half the group is given for boys and girls separately in Tables XXXV and XXXVI.

TABLE XXXIV. DISTRIBUTION OF B MEASURES (FROM LUMBAR BACK SUPPORT TO FORWARD EDGE OF SEAT CLOSE UNDER THE KNEES) FOR 3194 PUPILS OF BOTH SEXES AND OF ALL ELEMENTARY AND HIGH-SCHOOL GRADES

NOTE. For the true mean of each interval add .375 to number at head of each column and line.

SEAT-HEIGHT IN INCHES	B MEASURE IN INCHES												TOTAL
	9	10	11	12	13	14	15	16	17	18	19	20	
9	28	16	2										46
10	41	79	57	11	2								190
11	17	68	152	48	7	1							293
12		14	93	140	65	13	10	1					336
13		1	24	52	103	49	28	12	4	1			274
14			2	13	68	127	97	43	27	1	3		381
15			1	6	29	111	246	147	88	21	4		653
16					9	26	178	185	135	44	10	1	588
17						3	29	79	94	59	23	2	289
18							4	15	29	40	26	7	121
19									3	8	6	2	19
20									1	1	1	1	4
Totals . . .	86	178	331	270	283	330	592	482	381	175	73	13	3194

Mean of seat-height, 14.526 inches; of B, 14.652 inches; ratio, 1.009.

TABLE XXXV. DISTRIBUTION OF B MEASURES FOR 848 BOYS

NOTE. Add .375 for true interval value.

SEAT-HEIGHT IN INCHES	B MEASURE IN INCHES											TOTAL
	9	10	11	12	13	14	15	16	17	18	19	
9	13	5										18
10	24	37	22	1								84
11	7	31	52	15								105
12		4	28	41	7	1						81
13			3	4	16	6	7	1				37
14				3	17	37	22	5	2			86
15					3	35	76	28	11	1	2	156
16					3	3	68	55	35	7	3	174
17							3	29	33	13	7	85
18								3	7	6	4	20
19									1		1	2
Totals	44	77	105	64	46	82	176	121	89	27	17	848

Mean of seat-height, 14.268 inches; of B, 14.223 inches; ratio, .995.

TABLE XXXVI. DISTRIBUTION OF B MEASURES FOR 834 GIRLS

NOTE. Add .375 for true interval value.

SEAT-HEIGHT IN INCHES	B MEASURE IN INCHES											TOTAL
	9	10	11	12	13	14	15	16	17	18	19	
9	13	9	2									24
10	13	32	21	5								71
11	6	23	56	11	3							99
12		1	34	35	10	1	1	1				83
13		1	1	4	4	3	2	4				19
14				2	9	29	25	13	13	1		92
15					5	34	93	66	40	11		249
16					2	5	47	65	37	9	1	166
17							5	15	7	4		31
Totals	32	66	114	57	33	72	173	164	97	25	1	834

Mean of seat-height, 14.121 inches; of B, 14.356 inches; ratio, 1.017.

Relation of seat-height to seat-depth. Our question is to determine how deep the seat should be made for a given height of chair. This is a manufacturing problem, but is of general interest as a means of knowing when a seat is correctly proportioned. The measures show that for certain individuals this maximum seat-depth measure (B) varies approximately from three fourths (.740) to one and three-eighths times (1.374) the seat-height measure. But if we take the average (mean) for the more than three thousand cases tabulated, we find that the average seat-depth is 14.652 inches and that the seat-height average is 14.526 inches, which gives a ratio of almost exactly unity (1.009). We also find that the seat-depth measures for this group range from 9 to 20 inches, and that the seat-height measures have precisely the same range. But those who have the same seat-height measure vary as much as 8 inches among themselves in the seat-depth measure, and those who have the same seat-depth measure vary as much as 7 inches in seat-height; from all of which it is

quite clear that the simple method of averaging the figures cannot be used to decide how seats should be made.

For example, the 653 pupils whose seat-height is in the 15-inch group (from 15 to 15.75 inches) have an average seat-depth measure (B) of 15.8 inches. Now if these seats were made to this measure, the front edge of the seat would come exactly to the knee angle of the mid-sized pupils of the group, which is too long for them, as we have already explained. One hundred and forty-seven of the group would not touch the back by an inch or more if they sit erect. Only 25 would have as much as 2 inches' clearance between the edge of the seat and the knee joint. Obviously the seat is rather deep for the largest[1] of the group and altogether too deep for all the rest.

How long in the seat, then, should a chair or school desk be made to suit all these 653 pupils? For we must assume that it should be suitable for any of those who require and select a 15-inch-high seat. Can we make it short enough for the health and comfort of the smallest and roomy enough for reasonable free movement of the largest? Furthermore, we must answer the same question for every other height of seat, from the lowest to the highest, that is required. To make the answer general, it should be in terms of a proportion or percentage of the seat-height measure. The seat-depth must not be as great as the seat-height, but should it be 50 per cent, 75 per cent, or 90 per cent as great?

We know that the edge of the seat should not come within an inch of the under angle of the knee joint. We

[1] "Largest" means, of course, largest in this one (B) measure only. The long measure might be due to flesh on the back, to spinal conformation, or to lack of flesh below the knees, and has no constant relation to either weight or stature.

find by observation that the seat is uncomfortably short and confining if the edge is more than six or eight inches behind the joint for large persons and if more than three or four inches for little children. So we find what would be the seat-length for each seat-height if it were made, say, 70 per cent of the height, and then find from the measures tabulated just how far the edge of it would fall behind the knee joint for every individual of the 3194 when each is sitting erect. We try out the 80 per cent and 85 per cent proportions in the same way. The results are summarized in Table XXXVII. We see that if the 70 per cent ratio were used, only five of the 3194 would have the edge of the seat within an inch of the knee angle, only 3 per cent would have it within two inches; but 13 per cent would have it more than six inches behind the angle, and 32 per cent more than five inches behind. Considering the 80 per cent and 85 per cent ratios in the

TABLE XXXVII. DISTRIBUTION OF PUPILS OF TABLE XXXIV ACCORDING TO DISTANCE THAT SEAT-EDGE WOULD FALL SHORT OF KNEE-ANGLE IN SEATS OF SPECIFIED PROPORTIONS

DISTANCE FROM SEAT-EDGE TO KNEE-ANGLE IN INCHES	IF RATIO OF SEAT-DEPTH TO SEAT-HEIGHT WERE MADE		
	70%	80%	85%
2–2¾ (minus)			3
1–1¾ (minus)		11 (0.3%)	66 (2%)
1 (or less)	5	134 (4%)	340 (11%)
1¼–2	94 (3%)	543 (17%)	982 (31%)
2¼–3	319 (10%)	1028 (32%)	978 (31%)
3¼–4	865 (27%)	807 (25%)	534 (16%)
4¼–5	902 (28%)	441 (14%)	218 (7%)
5¼–6	598 (19%)	181 (6%)	63 (2%)
6¼–7	294 (9%)	43 (1.5%)	10
7¼–8	103 (3%)	6 (.2%)	
8¼–9	14 (1%)		
Totals	3194	3194	3194

same manner, it develops that the depth of seat which will most nearly suit all who should use it is not less than 80 per cent and not more than 85 per cent of the seat-height. At 80 per cent there will be about one third of 1 per cent, and at 85 per cent more than 2 per cent, of the whole group for whom the seat is so long that they cannot sit far enough back to get back support. But these can and should take a lower, and hence shorter, seat. We must not force those who have a long seat measure to take a seat too high in order to get a comfortable length, but we need not hesitate to ask those whose seat measure is short to take a lower one. Hence we eliminate from consideration these last (from 4 to 13 per cent of all) and find that the others are best provided for with seats whose length is somewhat less than 85 per cent and more than 80 per cent of their height.

Let us repeat that the depth of the seat referred to is not the length of the wood, but from the forward edge to a point just below the lumbar back support.

The problem in reality is far from being as simple as the foregoing would indicate, though even this much involves a large amount of calculation in the construction of Table XXXVII. While, in general, the conclusions are as given, there are variations in the results for the different seat-heights considered separately. The form and height of the lumbar back support introduce variable elements, since these determine how far back the pupil will ordinarily sit, as do the form of the seat bed and particularly of the forward edge of the seat. The conclusions stated above assume that these factors will be controlled according to the standards elsewhere developed in this and succeeding chapters. Various aspects of the problem which are important in the designing and construction of seats, and all the calculations and methods of using the numerical data in compiling this table, must be omitted in behalf of brevity.

Sex difference in ratio of seat-depth to seat-height. Measurements indicate that in some respects boys and girls (as well as men and women) differ in segmental proportions. Tables XXXV and XXXVI are given merely to show how the sexes differ in this seat-length (B) measure as compared with seat-height. The exact ratio of seat-depth (B) to seat-height (C) for the 848 boys is .995, and for the 834 girls it is 1.017; for the 3194 of both sexes in Table XXXIV it is 1.009. The boys of Table XXXV and the girls of Table XXXVI include all and only those found in the same classrooms. The difference is too slight to be appreciable, and indicates that if seats were being made or purchased for either boys or girls exclusively no distinction in this respect should be taken into consideration.

Anatomical determination of the seat form. *Forward edge.* It has already been shown that there should be no pressure or support from the seat under the forward part of the thigh; that any such support serves no useful sitting function, that it tends to be directly injurious because of pressure on nerves and blood vessels, and that it positively induces unwholesome posture. The degree to which such pressure is injurious is in direct proportion to the sharpness of the edge which is pressing. Therefore a fundamental requisite of a good seat is that the forward edge shall be well rounded. This means a round or curve in the front-rear line, so that the pressure under the thigh decreases and disappears gradually, not at an abrupt corner. It means a downward curve or round at the front edge. The deep saddle scoop under each thigh separately has the effect of lowering the forward portion of the seat (at least when the thighs are in the hollows), but does not lessen the need for the forward edge of the

seat in the scoops to be rounded downward. The sharp elevations between and at the sides of these scoops function only to restrict the movements of the legs. These scoops do not "fit" the thighs, except extremely fleshy ones, and there is no reason why they should. Nor is there any good reason why the seat should not be planed off clear across at the level of the bottom of the scoops. This would provide the same support and avoid the useless confinement. The scoops were evidently intended to avoid the distressingly common pressure under the knees. Why not adopt the more effective and simpler device of using a lower seat?

The sitting hollow, or scoop. In the commendable effort to add to the comfort of hard wooden seats, and especially to check the tendency of the ischial bones to slide forward on the seat, it has become a custom to scoop out more or less of a hollow in which the sitter is expected to sit. Sometimes this hollow is extremely developed into a supposedly "form-fitting" scoop. The theory of this extreme scoop is unsound for three reasons: (1) It cannot fit all forms which must occupy it. If large enough for the fleshy individuals, the smaller ones touch it only at the bottom. If small enough for the average or smaller individuals, the fleshy ones must be disagreeably cramped. The varying breadths of the pelvic frame render the misfit of a rigid form of the sort even more objectionable than the flesh pressures. (2) Support at the sides of the ischials is objectionable even to those whom it fits. The muscles do not form a cushion here, but are pressed up; the thigh bones are not formed to carry weight in this direction and tend to be twisted out of position; and the nerves and blood vessels which pass round and through the pelvis are exposed to pressure at the sides of the

ischials. (3) The position of the ischial bones on the seat with reference to the back support varies as much as ten inches for individuals requiring the same height and size of seat. Hence, whatever the position of this hollow, it is wrong for a large majority of those who are to occupy it — holding some of them so far from the back that they cannot get effective support and forcing others so far back that the pressure on spine and kidneys is uncomfortable or injurious.

So far as we can learn, no statistical information regarding this topic has ever been available prior to the making of this study. The following facts and figures therefore have especial importance and interest.

As explained in Chapter X our measuring apparatus was provided with a sliding saddle into which the ischial bones of each pupil fitted as he took his seat. He then slid back with this saddle as far as the knee angle permitted. A tape rolling on a spring coil indicated in a convenient place the exact distance from the center of the saddle to the edge of the seat under the knees. This is the measure D shown in Fig. 29, p. 119. By subtracting this measure from the measure B, the location of the resting point of the ischial bones (the sitting-point) with relation to the lumbar back support was accurately determined for every individual.

This D measure (from the sitting-point to the forward edge of the seat) was found to range from 5 to 15 inches and to vary approximately 6 inches for pupils of the same seat-height measure, and even more for each seat-length (B) measure. Table XXXVIII, on page 164, shows the distribution of this D measure in relation to seat-height (C) for 1100 pupils, and Table XXXIX, on page 164, shows its distribution in relation to B measure for the same group. These tables show conclusively the futility of attempting to fix the sitting-point on the seat with reference to the forward edge for any seat-height or seat-length group.

TABLE XXXVIII. CORRELATION OF D MEASURE (FROM THE SITTING-POINT TO EDGE OF THE SEAT CLOSE UNDER THE KNEES) WITH SEAT-HEIGHT FOR 1100 PUPILS OF ALL ELEMENTARY AND HIGH-SCHOOL GRADES

NOTE. For true mean of each interval add .375 to number at head of each column and row.

SEAT-HEIGHT IN INCHES	D MEASURE IN INCHES											TOTAL
	5	6	7	8	9	10	11	12	13	14	15	
9	1	1	1									3
10		8	14	6			1					29
11		6	23	25	5							59
12		2	12	45	45	17	2					123
13			2	15	53	61	21	9	2			163
14				4	17	40	49	22	6	3		141
15				2	11	29	50	66	23	6	1	188
16				1	3	14	29	65	51	25	7	195
17					1	1	7	24	33	29	20	115
18						1	1	9	12	26	24	73
19							1	1		1	7	10
20											1	1
Totals .	1	17	52	98	135	163	161	196	127	90	60	1100

TABLE XXXIX. CORRELATION OF B MEASURES WITH D MEASURES

NOTE. Add .375 to number at head of each column and row.

D MEASURE IN INCHES	B MEASURE IN INCHES												TOTAL
	9	10	11	12	13	14	15	16	17	18	19	20	
5		1											1
6	2	6	6	1	2								17
7	1	8	25	13	4	1							52
8		3	24	36	22	6	4	3					98
9			5	33	48	23	15	7	3	1			135
10			2	14	42	28	38	20	14	4	1		163
11			1	3	17	39	43	25	23	8	2		161
12			1	2	8	27	51	53	37	12	4	1	196
13					1	6	19	23	38	27	11	2	127
14							6	15	21	30	15	3	90
15								3	14	24	13	6	60
Totals. .	3	18	64	102	144	130	176	149	150	106	46	12	1100

TABLE XL. DISTRIBUTION IN RELATION TO SEAT-HEIGHT OF B-D MEASURE (DISTANCE OF THE SITTING-POINT FORWARD OF LUMBAR BACK SUPPORT) FOR 2776 PUPILS OF ALL GRADES AND BOTH SEXES

NOTE. Add .375 to number at head of each row only.

SEAT-HEIGHT IN INCHES	B–D MEASURE IN INCHES											TOTAL	MEAN
	−1	0	1	2	3	4	5	6	7	8	9		
9				8	26	10	2					46	3.13
10			8	26	90	49	17					190	3.22
11	1		11	46	128	82	19	3	3			293	3.24
12		2	15	59	126	84	33	10	4			333	3.30
13	1	2	12	45	80	67	36	9	2	1		255	3.39
14	1	4	15	49	95	81	37	18	4	1		305	3.44
15		5	26	64	164	112	70	29	11	4	1	486	3.57
16	2	4	30	75	149	111	54	22	14	3	1	465	3.45
17		2	15	42	69	65	49	16	3	3		264	3.61
18		1	2	16	23	33	27	12	2	1		117	3.97
19				1	6	5	2	2	2			18	4.22
20						3	1					4	4.25
Totals . .	5	20	134	431	956	702	347	121	45	13	2	2776	3.45
Per cents .	.2	.7	4.8	15.6	34.2	25.3	12.5	4.4	1.7	.5	.1	·100	

Table XL is even more impressive. It shows the B-D measure in relation to seat-height; that is, the exact position of the sitting-point (resting-point of the ischials) with reference to the lumbar back support. It is rather surprising to note that 5 individuals had this sitting-point actually 1 inch *behind* the back support, and 20 of them directly below it. These are the deep-curved or sway-backed type. On the other hand, 2 have this sitting-point 9 inches forward of the back support, and 60 of them more than 6 inches forward. A variation of 10 inches in this measure is found in the 16-inch-seat-height group alone. An important proportion of them vary through as much as 5 inches.

Current forms of this deep-scooped type of seat are made with the bottom of the hollow (in which the pupil is compelled to sit) about 5 inches forward of the back support. The table shows that 80 per cent of those measured should sit an inch or more closer than this. These 80 per cent are thus prevented from getting lumbar back support while they sit erect, and must relax

into some degree of slump to get relief for the back muscles. Observation of such seats in use fully verifies the facts indicated by the figures.

Furthermore, a deep scoop involves a more or less pronounced elevation just forward of the sitting-point and an abrupt one just behind it. As has already been pointed out, great nerves and blood vessels pass to the lower limbs through the holes in the ischial bones just over the tuberosities on which they rest and below the thigh bones. These nerves and blood vessels are not protected against pressure from below in the narrow area just in front of the ischials, where the flesh folds in as one stands. A sharp pressure at this point, even sitting on a thick coat wrinkle, promptly causes the legs to "go to sleep," or tingle. There should be no elevation of any sort which will press between the ischial bones and the thick pads of the leg biceps.

No elevation at the rear of the seat. It has also been previously pointed out that the muscles of the buttocks (*gluteus maximus*) do not function as cushions for upward pressure from the seat. They simply push up against the coccyx and, if the elevation is considerable, crowd these muscles and the coccyx up into the lower pelvis, where their pressure is seriously harmful. Pronounced elevation here compels one to "sit on the end of the spine" with discomfort and injury, even though he sits erect. Any elevation of the seat behind the sitting-point, if it functions at all, tends to slide the sitter forward and into a slumped posture. If it does not function, it is certainly useless. Hence why should there be any elevation behind the sitting-point? Why should there be any rise at the back of the scoop? If it is planed off level with the bottom of the scoop, each individual is free to slide

back in the seat until he gets the proper support from the back. But, of course, it is no longer a scooped seat. A slight hollowing of the seat from side to side is certainly unobjectionable and appears to contribute some element of comfort and attractive appearance (possibly psychological). In forming this lateral scoop it appears to be mechanically convenient and more tasteful in appearance to retain a slight elevation at the rear. There is no objection to this, *provided it is behind the back support,* where it cannot function to slide the sitter forward.

Formation of the seat. As stated above and explained in Chapter III, sitting-support from the seat should be under the ischial bones and the upper, or thick, portion of the thigh muscles. There should be no corner, ridge, or abrupt elevation to press into the flesh at any point. Since the muscles are compressible to a considerable extent before any pressure is exerted against the thigh bones, while the tissues under the ischials are stretched thin and compress scarcely at all, the forward portion of the seat support should be somewhat higher than the sitting-point or area in order that the weight may be shifted forward along the thighs when desired. It cannot be too often stressed that the ischials are the normal support in sitting just as the thigh sockets are in standing. Support along the thighs is primarily for relief from fatigue by bringing into action a varying combination of muscular tensions. The changing of these muscular tensions is accomplished mostly by moving the feet forward or back on the floor provided the seat is low enough, but there can be no shifting of pressure if it is too high.

In Fig. 30 are shown thirteen different forms of seats in common use on school furniture at this time. The profile is that taken along the line under the thigh and may

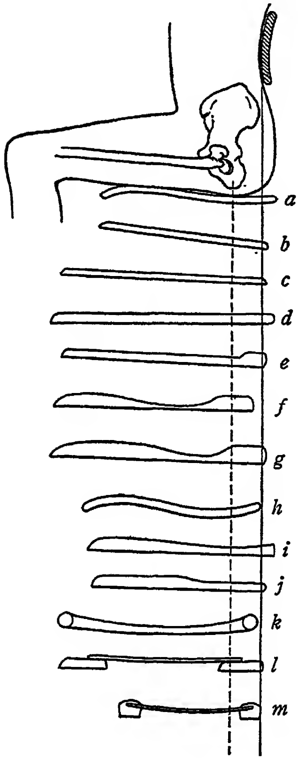


FIG. 30. Seat forms in use on school furniture. They are drawn to the same scale and in the same relation to the back support as indicated by *a* and by the vertical line. A section along the line of the thigh is shown

appear quite different from a line taken at the center or the side if the seat is scooped crosswise. In depth (length) the seats are relatively as shown, and as far as practicable their respective positions with reference to the lumbar back support are indicated by the vertical line. Many of them do not have the lumbar type of support, but the placing of the profiles is such that if the individual seated on *a* sits erect and uses the back support of each as far as practicable in that position, the location of the lumbar curve and ischial bones in each case will be as indicated by the verticals. There are, of course, many slight and greater variations from these, since no two designs of seats are exactly alike. The individual seated on *a* is average size for the sizes of seats shown. It is easy to see the difficulties to be encountered by those whose seat-length is shorter than the average.

Seat slope. A moderate backward slope of the seat tends gently to hold the sitter back in firm contact with the lumbar back support and to prevent the ischials

from sliding forward on the seat, both of which go far toward assuring good posture. This combination of lumbar support and seat slope accomplishes what has been vainly sought for by hollowing the seat. It permits and aids each individual to slide back on the seat to that particular sitting-point required by his own back conformation, and thus provides the only advantage of what is in effect a scoop automatically adjustable as far forward or back as desired. It automatically adjusts the back support forward or back to fit, but does it by moving the sitter back instead of moving the back slat forward. If the back support is suitable, the slope permits a perfect poise and complete relaxation of the trunk without the slightest tendency to slide into a stoop or slump. At the same time the tendency of the ischials to slide back rather than forward helps to insure a bend at the hips rather than at the waist as one leans forward to work on the desk; that is, to insure erectness rather than stoop.

The slope under the sitting-area should be very slight so as to produce a mere tendency to backward sliding and not a violent thrust. It should become level under the back support, because those whose sitting-point is this far back are already sway-backed, and there should be no additional tendency to increase the lumbar concavity. Five to eight or ten inches forward (in high-school or adult seats) the slope should be fairly great, since those who normally sit this far forward are somewhat stooped or fat-backed and require a gentle but continuous corrective pressure of just this sort; furthermore, the pronounced slope in this area makes slumping down in the seat a rather difficult performance. Forward again of this area the seat should flatten out under the thighs and turn its forward edge downward. These changes in slope

must not be made abruptly nor by a series of angles. When developed as a series of curves, the result is a form of which *a* in Fig. 30 is a conservative profile. By virtue of its rear elevation's being behind the line of back support, *i* has the same general effect though it is differently developed. Form *j* is developed on the same general theory as stated above, but the rise from the rear (sitting) plane to the higher forward plane under the thighs is made by relatively sharp angles instead of a long, sweeping curve.

Relation of slope to height and depth of seat. The more the seat is sloped the lower it should be, for the same individual. The knee-height does not increase whatever is done to the seat; hence any sloping must be either by lowering the sitting-point or by lifting the feet from the floor. In lowering the sitting-point, however, we necessarily slope the thighs uniformly from knees to hips. There is not the slightest objection to this changing of the angles at knees and hips nor the slightest justification for the very common insistence upon keeping them at right angles. But every point of the thighs is lowered proportionately to its distance from the knees, and unless the forward and highest part of the seat is also lowered, it becomes a point of undue pressure (Fig. 32, *C*). This means that if one sits on a sloping seat, it should be lower than his measured seat-height or there will be pressure from its forward edge.

Conversely, if one sits on a low seat, it ought to be sloped, but for another reason. When the knees are considerably higher than the sitting-point, the tissues under the ischial tuberosities are drawn very thin, and the pinching of them between bone and board becomes fatiguing and painful (Fig. 32, *B*). This is why the board seats in

circuses and stadiums are so atrociously uncomfortable. There are probably reasons why they cannot well be sloped; but they would be much more comfortable if made higher so long as they are only flat boards.

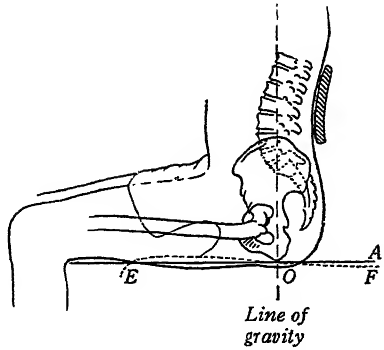


FIG. 31. Sitting-point (*O*) at measured seat-height. Flat seat (*A*) carries weight at (*O*) and at front edge if feet are moved so as to lower knees. Formed seat (*F*) distributes pressure along thigh muscles in proportion to their thickness, shifting pressure forward if knees are lowered

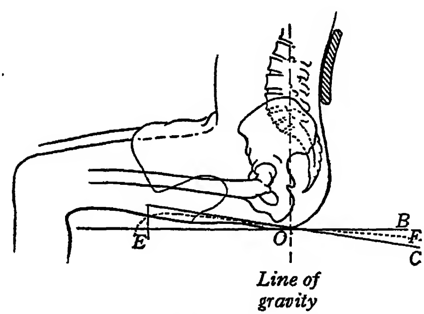


FIG. 32. Sitting-point (*O*) two inches lower than measured seat-height. Flat seat (*B*) presses at *O* only. Straight seat (*C*) sloped with front edge at full height presses mostly at edge (*E*). Formed seat (*F*) sloped half as much as *C* distributes pressure evenly

Additional reasons for the discomforts of these very low seats are in the pushing up of the thighs against the abdomen, tending to throw the body backward, while the muscles which sustain the poise of trunk from the inner side (great *psoas* and *quadrati lumborum*) are slacked and pushed back and those which tilt the pelvis backward with reference to the thighs (gluteal and leg biceps groups) are stretched taut. Thus the trunk is pitched backward, and, with no back support to counteract it, erect posture can be maintained only at the price of fatiguing tensions. Muscular relief is found only in letting the pelvis tilt back and throwing the

shoulders forward in an abandoned stoop. This is by no means a comfortable solution, but it is the line of least resistance unless the combination of upper and lower pressures on the abdomen creates too much discomfort.

A seat of the same height as the circus seat, sloped to correspond with the slope of the thighs and provided with a suitably formed and tilted support for the back, including the head, constitutes an ideal lounging chair of maximum comfort, approximating in form the best steamer chairs or the little low rocking chairs which our mothers and grandmothers preferred.

Again, if the seat is short, it should be sloped. That feeling of instability and lack of surface for free movement which is probably the only real objection to relatively short seats is largely overcome by a sense of firm support and lack of occasion or probability of movement. This is the effect of the gentle backward thrust given by the slope of the seat. The sloped seat should be short, not only for the same reasons that all seats should be short, but also because it assures that all occupants will sit as far back in the seat as practicable. Also, when the feet are moved forward and the knees lowered, the thighs approaching the horizontal (which should often occur to avoid fatigue), the relatively narrow ridge of pressure should be well back under the thick part of the thigh muscles, so that this change will be restful instead of painful. Finally, a sloped seat which is deep must either be too high at the knees or else be so low at the sitting-point as to make it difficult to rise.

Upholstered seats. All that has been said obviously refers to the hard, smooth finish of wooden seats. The principles derived from anatomy and bodily mechanics remain the same when applied to upholstered seats, but

these are supposed to conform automatically to the shape of the body whatever the variations of posture or individual form. A well-upholstered seat, so long as it remains well upholstered, contributes enormously to comfort and largely to good posture. The pressures and pinches are removed and the tendencies to slide into bad position are reduced if the general form of the seat is right. There are the same reasons for its being low and short and sloped as in hard seats. If we eliminate from consideration the expensive spring-cushion types of upholstery, the chief objection to cane, thinly upholstered, and other pliable seats is their tendency to sag toward the center, with use, leaving a deep hollow with a high and hard ridge on all sides, formed by the framework from which it is suspended. A more unhygienic and uncomfortable seat-bed than this would be hard to devise. The so-called "squab" seat has a thin pad of upholstery over a rigid wood or other solid base. This will not sag, but it seems difficult to find a material for the padding which will not be gradually pushed out from under the sitting-point and form into lumps. In this condition, of course, it is worse than any well-shaped

FIG. 33. Where seating reform is urgently needed

hard seat. The fact that upholstered seats will not stand up under the long and hard usage of the schoolroom is probably the main reason why they have not been introduced for school use. Most upholstering materials, either leather or fabrics, are neither sanitary nor durable as compared with a solid wood surface, and they are far more expensive as a rule. Then, too, the right of children to soft and comfortable seats has not been recognized. Cushioned seats are in general use in homes, offices, churches, places of amusement, public conveyances, and even in factories, and there is no argument for comfort, attractiveness, hygiene, or increase of efficiency that justifies their use in these places which does not apply with greater force to school use. Increase of cost should be no valid argument, since the whole cost of seating is so small in proportion to the total expenditure for education that any appreciable increase in educational or hygienic values or in the comfort and attractiveness of school seats would be worth far more than any possible difference in cost due to the upholstering. The rapidly and inevitably increasing cost of selected hard woods suitable for seats, and the still more rapid improvements in the appearance, durability, sanitariness, and other desirable features of upholstering fabrics, are fast removing the differential of cost. It may be practicable to make a renewable seat form, suitably upholstered, which can be replaced at a relatively slight cost when it wears out or deteriorates beyond the condition of satisfactory service. Children are entitled to such consideration, and it is to be hoped that soft seats will soon be available for them.

CHAPTER XIV

DETERMINATION OF THE SEAT BACK

Types of back support. Anatomically considered, three general types of back support are recognized according to the level at which they are placed; namely, shoulder, pelvic, and lumbar. Since the function of the seat back is to sustain the trunk in a hygienic, comfortable, and efficient position while the back muscles are relaxed, the type of back is to be judged by the posture which its use induces. They will be compared briefly from this point of view in order to make clear the reason for the particular data and interpretations presented in this chapter.

Shoulder support. When one relaxes against a support at the shoulder level, the spine sags under the support, reverses the lumbar curve, tilts the pelvis backward, and slides the ischials forward until a position approximating that in Fig. 6 is reached. In this position one is "sitting on the spine," the coccyx is crowded upward into the pelvis, the thorax and abdomen are compressed, and the viscera are crowded down upon each other and into the pelvis. As this position becomes habitual the back muscles are stretched and weakened, the spine loses its normal shape, and numerous derangements of more or less serious character are likely to occur. In sitting erect, no back muscles are relieved by support at this level.

Pelvic support. If support is against the rigid pelvic framework, it affords no relief for the muscles supporting the flexible portion of the trunk above this level. As the

back muscles relax and the lumbar curve is reversed, the support against the pelvis becomes a fulcrum against which the upper weight pries forward the ischial sitting-point, with the inevitable backward rotation of the pelvis and the general effect described in the preceding paragraph. Any continuous back rising from the seat, or close to it, in a nearly straight line makes this pelvic contact against the buttocks and functions primarily as a pelvic support. It also makes contact at the shoulder level, provided it is high enough, and therefore functions as both pelvic and shoulder support. In either case a considerable slump is necessary to secure any contact in the lumbar curve or any support for the back muscles.

Lumbar support. The only support that relieves the back muscles of their load, that permits them to relax while the trunk remains erect, and that tends to keep the pelvis erect and the spinal column poised upon it, with thorax and abdomen expanded, is that which is in the "small," or hollow, of the back, between the hips and the shoulder blades. There appears to be no difference of opinion among hygienists that this is the only hygienically correct type of back support and the only one which fosters good posture habits. The term "lumbar support" is used for the sake of brevity to designate this type of back, although it is to be understood that support is provided at both the upper lumbar and the lower thoracic levels. An extremely narrow support against the lumbar vertebræ only is likely to produce considerable strain on the spine and to endanger the kidneys. With a seat so shaped that the sitter slides firmly against the back, a properly formed lumbar support insures a poise which involves a minimum of exertion either for sitting erect or for the various movements incident to sedentary occupations.

Spindles, slats, and solid backs. Back supports are also distinguished as to type of construction, and confusion sometimes occurs by ascribing hygienic advantages or disadvantages to the method of building the back regardless of the form into which it is built. In view of what has been said above it is evident that straight, vertical spindles cannot provide lumbar support. Contact against them at any level is in ridges and hence is objectionable, particularly so if the spindles are of the knobby, turned variety (Fig. 34, *B*, 4, p. 188). Broad, flat-surfaced spindles bent to conform fairly well to the line of lumbar support are less objectionable and might be satisfactory. Crosswise slats may be placed at any height, and very often they are so placed as to afford pelvic and shoulder support only and to make lumbar support impossible. Very commonly a sharp under edge on a lower slat strikes against the receding slope of the back at the level of the sacrum, so that it not only fails to give proper lumbar support, but its discomfort insures that the sitter will slide forward and use only the shoulder support. If slats are placed in the same straight line, vertical or sloped, the effect is practically the same as with vertical spindles (Fig. 34, *A*, 2–6). Any sharp edge in contact with the person will, of course, make proper use of the back uncomfortable and probably insure bad posture, even though the slats themselves are correctly placed. A smooth, solid back at least avoids ridges, knobs, and irregularities of pressure. Whether it provides support where it should depends on the form of it (Fig. 34, *B*, 1, 2, 8). The difficulty of constructing a solid back with horizontal concavity combined with a vertical convexity is the chief reason why backs of this type can be used only in a limited range of construction types. A back curved in both

directions must be hollowed from a solid block of wood and is therefore expensive and cumbersome. Auditorium seats are commonly provided with solid backs having the horizontal concavity only, and most types of "combination desks" have a solid-back construction which is horizontally straight with a vertical curvature. Some of these latter are excellently formed according to the hygienic principle of lumbar support, although since they do not provide a recess for the buttocks, the effective support is provided only when one leans back and hence is not available when one sits erect for working on the desk. Probably the most popular and effective method of obtaining both vertical and horizontal curvature of the proper form is by means of two broad slats carefully designed to afford the upper and lower portions of the support desired (Fig. 34, *A*, 1). The gap of a few inches between them (provided the edges are properly rounded) makes no difference whatever in the effective support afforded, since there is no tendency for the spine to sag between them and hence no muscular strain is involved. This open construction probably has an additional advantage in avoiding the unnecessary contact and warmth which would result from a close-fitting solid form.

Horizontal form. It is usually supposed and is probably true that a moderate horizontal concavity increases the comfort of a seat back. Besides conforming better to the shape, it affords support for a certain degree of lateral leaning and turning in the seat. A deep, snug-fitting curve, however, is too confining for comfort. The line across one's back at the shoulders is practically straight, and a curvature in the support here tends to throw the shoulders forward and hinders expansion of the chest and related factors of erect posture. Combination seats,

church pews, and benches offer only backs horizontally straight and seem quite satisfactory as far as this factor is concerned. A horizontally straight support below the shoulder blades is not only comfortable but is particularly conducive to expansion of the chest and falling back of the shoulders.

Height of back. Tradition or other influence has led to a very general tendency toward too much lumber in the backs of most chairs as well as in the seats. Backs are almost invariably too low to afford a head rest (which rest may be altogether desirable in a chair intended for relaxation) and yet are so high as to afford such contact on the shoulders as to prevent restful support of the back muscles. In a school seat, intended strictly for working purposes, the head rest is not to be considered, and, as with the seat, the back should contain not an inch of surface which does not serve some useful supporting function. The resulting form is surprisingly small and low and is more than likely to be regarded with prejudice until its genuine advantages are fully understood and demonstrated.

Earlier studies of the subject. The best study of the back support is that made by Dr. Frederic J. Cotton in Boston in 1904.[1] By extensive measurements and experiments with wooden shapes covered with modeling wax, he sought to find the particular shape which would afford the best support and greatest comfort. His report summarizes his conclusions as follows:

The model finally settled on consists of a curved support of wood $9\frac{3}{4}$ inches wide and 5 inches high, with a concavity of 1 inch in depth from side to side, with a convexity of 1 inch in profile, the whole tilted very slightly backward. The maximum convexity lies one third of the way up, and when properly adjusted comes about opposite or a little

[1] "School Furniture for Boston Schools," *American Physical Education Review*, Vol. IX, pp. 267–284.

above the fourth lumbar vertebra. This support is carried on a light casting running in the groove of a single cast-iron upright attached to the back of the seat A set screw fixes the height after adjustment. Two models for back rests were worked out independently by means of modeling wax and wood, one for older and one for younger children. The curves were found to be identical. A third model was found to be desirable for adolescent girls on account of their larger hips. This form was placed slightly higher and had flattened lower corners.[1]

Since Dr. Cotton provided a vertical adjustment, his study gives no comparable height measurements.

The following figures are taken from the tables of Cardot's measurements in Paris:[2]

Height of pupil in centimeters . .	100–110	110–120	120–135	135–150	150 or more
Height of lumbar curve from seat	16	17.5	20	22	24
Seat-height . . .	28	31	35	40	46

Information is lacking as to the precise method used in locating the lumbar curve, but the ratios of the height of the lumbar curve from the seat to the seat-height are approximately the same as shown in Table XLI, on page 183, and are as follows: .57, .56, .57, .55, and .52 respectively.

Flexible-rule study of back shapes. On the first six hundred subjects measured in securing the data for this report the writer made use of a flexible curve rule by means of which the precise form of the back profile for each individual was taken and traced on a roll of coördinate paper. After studying a large number of these a composite curve was derived which when shifted in

[1] The writer recently visited several Boston schoolrooms in which these back forms were still in use. Both teachers and pupils, so far as interviewed, expressed dislike rather than liking for them. The difficulties seemed to be (1) that they are not adjusted, (2) that the curvature is too pronounced to fit some individuals comfortably, (3) that they restrict the position and movements of the sitter too rigidly, and (4) that the vertical casting to which they are attached, being too straight, comes in contact with the body at the level of the sacrum or coccyx.

[2] Dufestel, Hygiène Scolaire, chap. v.

vertical position and rotated slightly was found to correspond very closely with most of the tracings. A wooden form was made according to this curve and tried upon approximately a hundred individuals with the result that, by adjusting vertically within a range of two inches and altering the slope within a range of slightly more than one inch at the upper end, it seemed to fit all of them with two or three possible exceptions. The vertical shape of this back form may be described fairly as the arc of a circle of radius of eight inches extending above into a slightly curved tangent at eighty degrees from the horizontal and rounded off below on a tangent of forty-five degrees. There was no horizontal curvature. By pivoting this surface slightly about an eccentric point near the crest of the curve, a series of curves are derived which vary in form relative to a vertical line and in the position of the crest relative to the pivoting-point. Further experimenting is necessary to determine whether such a pivoted form can be practically arranged to fit automatically all backs within a certain range of hip-height and shoulder-blade height. If so, then, by providing a practical vertical adjustment in addition, it is conceivable that a universal-fitting back might be evolved, though it would probably not be practicable for school purposes.

Statistical determination of dimensions. In view of the elusive character of the lumbar curve as modified by individual variation of segmental development, by postural habit, and by flesh conditions, the statistical data here presented are confined to vertical measurements. The "hip-height," or level of the crests of the ilia, which corresponds with the height of the middle of the fourth lumbar vertebra, was fixed upon as the most reliable and ascertainable skeletal point by which to mark the level of the greatest curvature of the lumbar concavity. Below this point the spinal profile necessarily slopes backward if one sits erect. Above this the spine normally and usually curves back toward the thoracic convexity. The

actual curve varies considerably among individuals, the apparent crest of the curve sometimes appearing to be considerably higher because of sitting habits or flesh conditions. This is, however, the lowest point for actual support for the flexible portion of the spine, since contact below this is against the rigid pelvic frame. The upper limit of support is fixed at the points of the shoulder blades, the shoulders hanging well back and down, since contact against the shoulder blades themselves supports the spine only indirectly through the whole mass of shoulder-girdle structure, and, as has already been said, relieves the back muscles only when the spine has sagged below them. Support against the shoulders also interferes with free arm movement. Our problem is to determine for each seat-height the upper and lower limits of back support required for those who are to use the seat.

Tables XLI and XLII, respectively, show the distribution, for each seat-height interval, of the height of the iliac crests from the seat (E, or hip-height) and the height of the points of the shoulder blades from the hip-height level (G, or back-length) for 3190 individuals of all school grades. The correlation of hip-height to seat-height calculated for 1500 cases was found to be .76, and that of back-length to seat-height for the same group was .59, while the correlation of hip-height to back-length for 200 girls was found to be but .236. Table XLIII, on page 184, shows for each seat-height interval the corresponding mean hip-height (from Table XLI) and its ratio to the seat-height, also the mean back-length (from Table XLII) and its ratio to the seat-height. This table discloses a notably uniform increase of both these measures parallel with the increase of seat-height, together with an equally remarkable uniform decrease of the ratios. If these means and ratios were acceptable as a basis of seat construction, a relatively simple rule of proportions could readily be derived from them.

TABLE XLI. DISTRIBUTION OF E (HEIGHT FROM THE SEAT TO THE LUMBAR CURVE AT THE ILIAC CRESTS) IN RELATION TO SEAT-HEIGHT FOR 3190 PUPILS OF ALL GRADES AND BOTH SEXES

NOTE. Add .375 to head of each column and line for true interval value.

SEAT-HEIGHT IN INCHES	E MEASURE IN INCHES								TOTAL	MEAN	RATIO
	4	5	6	7	8	9	10	11			
9		4	29	12	1				46	6.57	.70
10		45	111	32	1		1		190	6.34	.61
11	2	31	150	93	15	2			293	6.70	.59
12	2	13	110	186	25				336	7.03	.57
13		1	31	138	89	12	2	1	274	7.70	.57
14		2	14	113	167	74	7		377	8.22	.57
15	1	3	5	85	299	227	32	1	653	8.66	.56
16			1	22	202	318	43	2	588	9.03	.55
17				8	56	162	59	4	289	9.36	.54
18				1	9	61	48	3	122	9.73	.53
19						9	8	1	18	9.93	.51
20							4		4	10.00	.50
Totals .	5	99	451	690	864	865	204	12	3190	8.19	.56

TABLE XLII. DISTRIBUTION OF G (BACK-LENGTH FROM THE ILIAC CRESTS TO THE POINTS OF THE SHOULDER BLADES) IN RELATION TO SEAT-HEIGHT FOR 3190 PUPILS OF ALL GRADES AND BOTH SEXES

NOTE. Add .375 to head of each column and line for true interval value.

SEAT-HEIGHT IN INCHES	G MEASURE IN INCHES								TOTAL	MEAN	RATIO
	4	5	6	7	8	9	10	11			
9	11	26	9						46	5.33	.57
10	43	121	26						190	5.29	.51
11	47	165	78	3					293	5.50	.48
12	27	170	120	19					336	5.76	.47
13	13	108	115	33	5				274	6.12	.46
14	9	90	167	89	17	4		1	377	6.45	.45
15	8	77	245	223	71	26	2	1	653	6.93	.45
16	1	37	195	219	107	26	3		588	7.20	.44
17	1	15	81	98	75	18		1	289	7.37	.42
18		4	29	46	27	13	3		122	7.58	.41
19			1	8	5	4			18	8.05	.41
20				1	2	1			4	8.37	.41
Totals .	160	813	1066	739	309	92	8	3	3190	6.55	.45

TABLE XLIII. MEAN HIP-HEIGHT (E), MEAN BACK-LENGTH (G), AND RATIO OF EACH TO SEAT-HEIGHT, FOR EACH SEAT-HEIGHT INTERVAL FOR 3190 PUPILS OF ALL GRADES

MEAN SEAT-HEIGHT	MEAN HIP-HEIGHT	RATIO	MEAN BACK-LENGTH	RATIO	NUMBER OF CASES
9.375	6.57	.70	5.33	.57	46
10.375	6.34	.61	5.29	.51	190
11.375	6.70	.59	5.50	.48	293
12.375	7.03	.57	5.76	.47	336
13.375	7.70	.57	6.12	.46	274
14.375	8.22	.57	6.45	.45	377
15.375	8.66	.56	6.93	:45	653
16.375	9.03	.55	7.20	.44	588
17.375	9.36	.54	7.37	.42	289
18.375	9.73	.53	7.58	.41	122
19.375	9.93	.51	8.05	.41	18
20.000	10.00	.50	8.37	.41	4
14.526	8.19	.56	6.55	.45	3190

As a means of discovering how the individuals of the various seat-height groups are related in respect of these back measures to the means shown by the tables, various tabulations have been made to show the relation of hip-height (E) to back-length (G). The data for sample groups of the 15-inch and 16-inch seat-heights are shown in Tables XLIV and XLV. From Table XLIV it is seen that if the 248 children of this group, having a seat-height of from 15 to $15\frac{3}{4}$ inches, were provided with a back support with the lower edge at their mean hip-height (8.68 inches), all (106) of the median group, three fourths (69) of the next higher group, and one fourth (7) of the next lower group, or a total of 182 (73 per cent), would be fitted within less than 1 inch; similarly calculating, 56 others would be fitted within 2 inches, leaving only 10 (4 per cent) whose measured hip-height varies more than 2 inches from the mean. In like manner, if all these 248 individuals were provided with seat backs of the mean vertical length or height (7.06 inches), 150 (60 per cent) would be fitted under the shoulder blades within 1 inch, 74 others (30 per cent) would be fitted within 2 inches,

TABLE XLIV. DISTRIBUTION OF BACK-LENGTH (G) IN RELATION TO HIP-HEIGHT (E) FOR 248 PUPILS OF THE 15-INCH-SEAT-HEIGHT GROUP

NOTE. Add .375 to head of each column and line for true interval value.

Back-Length (G) in Inches	Hip-Height (E) in Inches								Total
	4	5	6	7	8	9	10	11	
4		1			1				2
5			2	6	12	8	1		29
6	1	1	1	16	37	29	5	1	91
7		1		4	35	27	6		73
8				1	14	17	1		33
9				1	6	8	2		17
10					1	1			2
11						1			1
Totals	1	3	3	28	106	91	15	1	248

TABLE XLV. DISTRIBUTION OF BACK-LENGTH (G) IN RELATION TO HIP-HEIGHT (E) FOR 341 PUPILS OF THE 16-INCH-SEAT-HEIGHT GROUP

NOTE. Add .375 to head of each column and line for true interval value.

Back-Length (G) in Inches	Hip-Height (E) in Inches						Total
	6	7	8	9	10	11	
4			1				1
5		2	8	13	2		25
6	1	5	52	70	7		135
7		5	56	60	8	1	130
8		5	16	18	2	1	42
9		1	3	1			5
10		1	2				3
Totals	1	19	138	162	19	2	341

leaving 24 (10 per cent) whose shoulder blades would vary two inches or more from the top of the back support.

It is interesting to note from this table that although 96 per cent are accommodated within 2 inches of the mean hip-height and 90 per cent within 2 inches of the mean back-length,

still there is one individual in this group with a hip-height of 11 inches, one with a back-length of 11 inches, and three with the sum of back-length and hip-height of 11 inches or less; that is, these three should have the top of the back support at or below the height at which the bottom of it should be for a fourth.

Fortunately the range of distribution of these two measures is not as great in the other seat-height groups as in the illustration just given. A more nearly typical distribution is shown in Table XLV, in which we find that of 341 pupils of the 16-inch-seat-height group, 329 (96 per cent) are included in a variation of two inches from the mean in both hip-height and back-length measure, and 288 (84 per cent) are included in a variation of one inch in both measures.

If the bottom of the back support were as high as the highest hips and the top of it as low as the lowest shoulder blades, the support would be but one inch wide for the 16-inch-seat-height group and would disappear entirely for the 15-inch group. Hence our anatomical limits cannot be used practically as construction limits. Support must be provided, and it will come below the hip-height level for some and above the tips of the shoulder blades for others. Therefore it must be so shaped as to do no violence to these individuals and yet provide adequate and comfortable support for all. Upper and lower edges, like the front edge of the seat, should round away from the contact so as to afford no corner of pressure wherever they may strike.

Slope of the back. While no one slope is equally well adapted for all individuals, the back can be so designed that each can adjust himself to it by sitting slightly farther forward or back, provided the sitting-point is not fixed by the shape of the seat. In determining the slope of the back, the slope and shape of the seat should be considered, also the position of the desk top if the seat is

to be used with a desk, and the nature of the work for which the desk is primarily intended. A back support which is expected to function when one is writing should obviously be more nearly vertical than one which is expected to be used primarily by a sitter who is looking upward toward a screen, a blackboard, or an instructor. To place the support so that it will be equally effective for either purpose and for reading with one's book in various positions involves a number of further considerations relative to form of back and seat and their relations to each other, as well as details of observations and experiments which cannot profitably be entered into here.

Varied types of backs. In Fig. 34 are shown profiles of a number of back forms which have been extensively used on school seats during the past few decades. Some of the more extreme of the European forms will seem strange to American readers, but all of them have been seriously advocated and used with approval, and the majority have been at one time or another officially adopted by some municipality or state government. Discussions of them will be found in the leading European works on school hygiene.

Even if we assume that in each instance the height dimensions are suited to the sitter, the effect of these various forms on sitting-posture and spinal development must be varied indeed. But since, as shown by our statistics, the height, whatever it is, will be more or less incorrect for the majority of those who use the seat, the danger of the more radical forms is apparent. It should be said that every one of the European forms shown was designed as hygienically superior on the basis of some anatomical theory, but some of them obviously without adequate knowledge of skeletal mechanics or the great

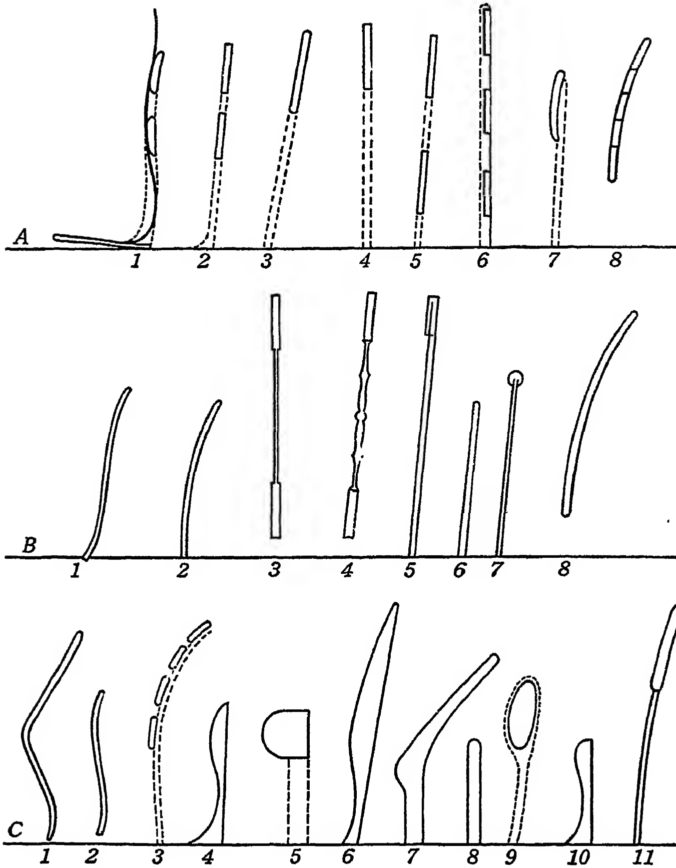


FIG. 34. Various types of back supports used on school seats. First row: slat or cross-strip backs. Second row: vertical spindles or solid backs. Third row: various types used in European schools. All are sections along the center line

diversity of segmental measurements to be found among children of approximately the same stature. The lesson from these diverse forms is one of conservatism. Whatever

the back form, it must be such as will do no violence to individuals varying two inches in either direction from the average which it assumes.

Adjustable backs. Adjustable back supports have been tried in various designs. Like other adjustable features, they suffer from two unfortunate facts: they are seldom

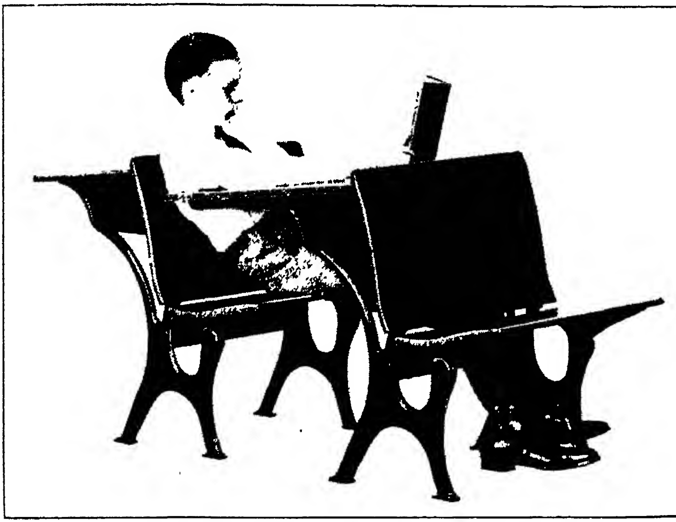


FIG. 35. An objectionable sort of back support

adjusted at all, and when adjustments are attempted they are as likely to be wrong as right. Even the elaborate adjustable backs on the chairs of office stenographers and typists are more often than not quite out of adjustment, although used only by one individual. The writer has made a special point of visiting a number of classrooms where seats with adjustable backs are provided. In every such room a majority of these back supports were very badly placed, the support intended for the lumbar curve

being usually found at the height of the shoulder blades. In some cases, indeed, the shape of the back as a whole in relation to the form of the seat was such that the intended lumbar support was impracticable despite the adjustable feature. In other cases ignorance and neglect, together with the influence of acquired habits of improper sitting, were responsible. Even if the mechanical difficulties were overcome, it is not clear that any adjustable back form devised is superior to the best-shaped fixed backs for school seats, but in any case that superiority must depend on the thorough training and conscientious attention of pupils and teachers in the proper use of it. For horizontal adjustment no back device is as good as a seat so designed that the sitter is automatically adjusted to the back support.

Resiliency. Perhaps more desirable than a mechanical device requiring effort and attention to get it in (or out of) correct adjustment would be an automatic yielding construction. A slight resiliency which would absorb the larger part of the incessant shocks that now are transmitted directly to the spine of the pupil might accomplish much in the way of relieving fatigue and nervous strain. This might be in the form of a pivoting movement which permits the support to turn so as to conform easily to the slope and form of the individual back, at the same time breaking the jar of contact.

Upholstery. Both resiliency and a practically perfect fit so far as minor variations of form are concerned would be effectively attained by a suitable upholstered back. Everything said as to upholstered seats in the preceding chapter applies with additional force to backs. It is the writer's opinion that the ultimate solution of the problem of back support will include upholstering.

CHAPTER XV

DESK-HEIGHT, SLOPE, AND SPACING

Definition of terms. The term *desk-height* is used to mean the height of the desk surface at the edge nearest the sitter.

Manufacturers more often use the term to refer to height at far edge or over all, but these measures have no relation to requirements of the pupil. Correct desk-height is usually assumed to be that most favorable for good posture in writing. Just how this is related to anatomical measures of the pupil it is the primary purpose of this chapter to determine.

Difference is a term long used by school hygienists to mean the difference between desk-height and seat-height as we have defined them. It is found by measuring vertically from seat to desk edge or by subtracting seat-height from desk-height.

The *slope* of the desk surface is expressed in degrees from the floor or horizontal plane.

Distance is the word regularly used to describe the *spacing* of the desk relative to the seat. Because *distance* has been traditionally applied to an utterly irrelevant measure (from the front edge of the seat), the word *spacing* will be generally used in this discussion and will mean the horizontal measure from the near edge of the desk to the back support.

Suitable distance has properly been regarded by hygienists as a most critical element in good posture, but it has unfortunately been expressed in terms of the position of the near edge

of the desk relative to the forward edge of the seat: a "minus distance" being the amount by which the desk edge overhangs the seat, a "zero distance" meaning that the edge of the desk is directly over the edge of the seat, and a "plus distance" being the amount by which a vertical let fall from the desk edge is forward of the seat edge. A "minus distance" of about two inches has been commonly given as the correct spacing for writing.

The question of interest in spacing seat to desk is where does the pupil sit, and, as we have seen in Chapter XIII, this has no relation to the front edge of the seat. The factors which determine where the pupil will sit are the back support or the form of the seat-bed. We have also seen that the seat should not be formed so as to prevent the pupil from making full use of the back support, and that the latter should be at the lumbar level. This back support at the lumbar level thus becomes our point of reference for measures of seat-depth (front to back), form, and *spacing.*

This theoretical spacing standard cannot be applied practically to seats which have no back support at the lumbar level or whose backs or seats are such that pupils cannot use them while sitting erect. If, when a pupil sits erect at that place on the seat where its form compels him to sit, the back support is four inches behind his back, obviously that seat requires four inches more space in order that the pupil may sit in the same position relative to the desk edge. Hence greater spacing is required for any seat in which the lumbar back support does not function than for one in which it does.

Determination of the desk-height. There is no anatomical measure which may be taken directly as the desk-height (as the angle under the knees is taken as the seat-height). The nearest measure that can be taken from the pupil as a guide to correct desk-height is the height of the elbows in "correct writing position." But there are so many variable factors, opinions, and standards of correctness in writing position, that any measures

would have to be based on conclusions about correctness, which it is the very purpose of the measuring to establish. Therefore the *elbow-height*, taken as the pupil sits erect at measured seat-height and with shoulders well back and down and elbows close to the sides, is used as a basic anatomical measure from which the desk-height is to be determined.

The elbow-height has quite commonly been naïvely used as desk-height without comment. Cardot, Baudin, and some others use "the pit of the stomach of the child when properly seated" as the correct measure for desk-height. Others have used the height of the navel or the tip of the sternum. These points differ considerably, and the elbow-height might be at any or none of them. Dufestel, although indorsing Cardot's method of measuring (in Paris), remarks: "Cardot has made the desks too low. All foreign models are higher."

All such somatic landmarks have been rejected in this study, not only because of the difficulty of obtaining or applying them in school practice, but also because of the lack of any definite connection between such anatomical points and writing or other activities related to the desk. Posture in desk work is determined primarily by the relation of the elbows to the desk, and while the elbow-height is not the desk-height, there is obviously a definite relationship between them.

Statistical studies of desk-height have been made with the object of finding a definite relationship which the height of the desk should bear to that of the seat. Manufacturers have had to assume some such relationship and to assign some height to the desk which accompanies each height of seat. Educators have sought a ready way of determining both seat-height and desk-height from some convenient measure of the pupil, preferably his standing-height. What has been demanded is a general rule which would answer the question Given the

height of the pupil or of the seat, what is the correct height for the desk? The most convenient sort of answer would naturally be a simple ratio; for example, a commonly accepted (though inaccurate) rule has been that the desk should be three sevenths of the height of the child and half as high again as the seat. Dresslar ("School Hygiene," p. 89) states that a safe rule "is to make the front edge as high as three sevenths the height of the child, plus an inch" in elementary grades, or plus a half-inch in primary grades. We shall find that no such simple rule can be correct with any degree of accuracy. We present below some of the most closely comparable studies and our own measurements made in the effort to answer the question.

Comparable data. In the study by Dr. Stecher referred to in Chapter XI he measured the "desk-height" from the top of the book held under the feet of the child sitting on top of a flat table "to the under side of the horizontal forearm, the upper arm being held close to the side of the body." He gives this as "the lowest height of the desk." His method gives too great a seat-height measure, as explained in that connection, and this same excess would be included in the measure of elbow-height, which he calls desk-height. He found the following range of desk-heights for the indicated seat-heights, from which we derive the ratios shown in the last columns.

Seat-Height or "Leg Measure" in Inches	Range of "Desk-Heights" (Elbow-Heights) in Inches	Ratios
12	19–22	1.58–1.83
13	20–23	1.54–1.77
14	19–25	1.36–1.79
15	21–26	1.40–1.73
16	21–28	1.31–1.75
17	23–30	1.35–1.76
18	25–30	1.39–1.66
19	28	1.47

Stecher summarized the "manufacturers' standards" (in inches) as follows:

Desk Number	Age of Pupils	Height of Seat	Height of Desk	Ratio (of Averages)
6 . . .	4–6	$11–11\frac{5}{8}$	$20\frac{3}{4}–21\frac{1}{4}$	1.83
5 . . .	7–9	$12\frac{1}{4}–12\frac{1}{2}$	$22\frac{1}{4}–23$	1.83
4 . . .	10–13	$13\frac{1}{2}–13\frac{3}{4}$	$24\frac{1}{2}–24\frac{3}{4}$	1.79
3 . . .	13–16	$14\frac{1}{4}–14\frac{3}{4}$	$25\frac{3}{4}–26\frac{1}{2}$	1.80
2 . . .	17–20	$16–16\frac{1}{8}$	$27\frac{1}{4}–28\frac{1}{4}$	1.73
1 . . .	Adults	$17\frac{1}{8}–17\frac{1}{4}$	$29\frac{1}{2}–30$	1.71

The Vienna standards referred to in Chapter XI include the following (in centimeters; from Burgerstein and Netolitsky, "Handbuch der Schulhygiene"):

Height of Pupil	Desk-Height	Seat-Height	Ratio of Desk-Height to	
			Height of Pupil	Seat-Height
102–117 . .	54	31	.49	1.74
118–125 . .	56.5	32	.46	1.73
126–134 . .	61	34	.47	1.79
135–144 . .	63	36	.45	1.75
145–154 . .	67	40	.45	1.68
155–164 . .	71	42	.44	1.69
165–174 . .	75	45	.44	1.67

The following (in centimeters) are from the tables of Cardot previously cited (Dufestel, "Hygiène Scolaire," chap. v):

Height of Pupil	Desk-Height	Seat-Height	Ratio of Desk-Height to	
			Height of Pupil	Seat-Height
100–110 . .	45	28	.44	1.64
110–120 . .	51	31	.44	1.65
120–135 . .	58	35	.45	1.66
135–150 . .	66	40	.46	1.65
150 up . .	75	46	.48	1.65

TABLE XLVI. CORRELATION OF ELBOW-HEIGHT (A) WITH STANDING-HEIGHT FOR 1500 PUPILS OF BOTH SEXES AND ALL GRADES

NOTE. Add .375 to head of each column and row for true interval value.

STANDING-HEIGHT IN INCHES	ELBOW-HEIGHT (A) IN INCHES															TOTAL
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
40			1													1
41	2		1													3
42	2			1												3
43	3	5	2													10
44	1	2	5	1	1											10
45		6	13	1	2											22
46	1	5	9	2	5											22
47		3	8	10	6											27
48		1	6	21	12											40
49			2	15	18	3										38
50			1	17	25	6		1								50
51				17	43	16	1									77
52				6	29	20	3	1								59
53				2	19	30	17									68
54					11	35	11									57
55				1	6	28	20	2								57
56					5	16	12	8								41
57					1	11	27	24		1						64
58					4	4	14	14	6	1						43
59					1	2	6	16	11	4						40
60					1	2	7	22	13	5						50
61							4	5	24	8	1					42
62							1	14	38	24	4					81
63							1	9	27	33	12					82
64						1		8	21	42	21	4				97
65								4	10	34	33	6				87
66								1	5	14	32	18	1			71
67									3	15	31	20	4			73
68								1	1	2	17	15	10			46
69										3	14	17	14	1		49
70										1	3	17	12	5		38
71											1	8	10	6		25
72													9	4		13
73													2	3	1	6
74												1	1	3	1	6
75															2	2
Totals	9	22	48	94	189	174	124	130	159	187	169	106	63	22	4	1500

Elbow-height measures and ratios. The tabulation of our own measurement of 1500 pupils of all grades (Table XLVI) gives a mean ratio of elbow-height to

standing-height of .395; that is, the average elbow-height is slightly less than two fifths of the standing-height.

This is considerably less than any of the French or Austrian standards for ratio of desk-height to standing-height, and less than the common rule that the desk-height should be three sevenths of the stature plus one-half inch in the primary or one inch in the upper grades (.44 to .445). But since our elbow-height measure is not desk-height, and we have no data as to how the others were measured, the comparison is not important. It is interesting to note in the figures given above that in the Vienna figures the ratio decreases as stature increases, whereas in the French figures the ratio increases with stature.

The mean ratio of elbow-height to seat-height for 3362 pupils of all grades is 1.594 (Table XLVII, on page 198), with individual ratios varying from 1.33 to 2.22. That is, for the group average elbow-height is one and three-fifths times seat-height, but for individuals elbow-height varies all the way from one and a third to more than twice seat-height.

Of more practical importance is the *difference*, which for present purposes we must consider as the difference between seat-height and elbow-height; or the height of the elbows, as measured, from the seat. We find that this measure averages 8.77 inches for the group of 3362 pupils, whose average seat-height is 14.40 inches (Table XLVIII, on page 199). But, what is far more significant, is the fact that for practically every seat-height group we find a variation of from 5 to 8 inches in this difference, and the same difference-measure is found in pupils varying as much as 11 inches in seat-height. For example: pupils whose seat-height is 15 inches have the difference-measure anywhere from 5 to 13 inches, and those whose difference-measure is 8 inches are found

TABLE XLVII. CORRELATION OF SEAT-HEIGHT (C) WITH ELBOW-HEIGHT (A) FOR 3362 PUPILS OF ALL GRADES

NOTE. Add .375 to head of each column and row for true interval value.

ELBOW-HEIGHT (A) IN INCHES	SEAT-HEIGHT (C) IN INCHES												TOTAL
	9	10	11	12	13	14	15	16	17	18	19	20	
16	10	15	1										26
17	42	102	28	2									174
18	9	96	113	9	1								228
19		28	164	111	9	1							313
20	2	8	62	162	72	11	4						321
21		1	1	59	118	73	6		1				259
22			1	3	55	110	47	1					217
23				2	14	115	153	30	3				317
24					5	50	233	123	11				422
25					1	20	147	215	58	2			443
26				1		1	56	162	100	18	1		339
27							6	55	82	45	1		189
28							1	2	31	39	8	2	83
29									3	16	8		27
30										1	1	2	4
Totals . . .	63	250	370	349	275	381	653	588	289	121	19	4	3362

Mean of A, 22.96 inches; mean of C, 14.40 inches; mean ratio, 1.594.

from kindergartners whose seat height is 9 inches, up to some very tall high-school boys who take a 20-inch seat.

The elbow-height increases and decreases pretty closely with the seat-height (correlation, .93) because the former includes the latter as its chief part; but when we compare the measure from the seat to the elbow with that from the seat to the floor, we find there is very slight relation between them (correlation, .29). There is decidedly less correspondence between these two measures than would be anticipated from the mere general increase in size, unless we stop to consider just what size it is that we are measuring in the *difference*. One's arms and legs usually grow at about the same rate, but not at the same rate that the trunk grows. The longer the legs, the higher

TABLE XLVIII. CORRELATION OF SEAT-HEIGHT (C) WITH DIFFERENCE BETWEEN SEAT-HEIGHT AND ELBOW-HEIGHT (A − C) TRANSFORMED FROM TABLE XLVII BY REARRANGING FOR A − C VALUES

NOTE. Add .375 to head of each column only for true interval values.

DIFFERENCE (A − C) IN INCHES	SEAT-HEIGHT IN INCHES												TOTAL
	9	10	11	12	13	14	15	16	17	18	19	20	
4									1				1
5			1	2	1	1	4						9
6		15	28	9	9	11	6	1	3				82
7	10	102	113	111	72	73	47	30	11	2	1		572
8	42	96	164	162	118	110	153	123	58	18	1	2	1047
9	9	28	62	59	55	115	233	215	100	45	8		929
10		8	1	3	14	50	147	162	82	39	8	2	516
11	2	1	1	2	5	20	56	55	31	16	1		190
12					1	1	6	2	3	1			14
13							1						1
14				1									1
Totals . . .	63	250	370	349	275	381	653	588	289	121	19	4	3362

TABLE XLIX. MEAN ELBOW-HEIGHT, MEAN DIFFERENCE BETWEEN SEAT-HEIGHT AND ELBOW-HEIGHT, AND RATIO OF MEAN ELBOW-HEIGHT TO MEAN SEAT-HEIGHT, FOR EACH SEAT-HEIGHT GROUP (DERIVED FROM TABLES XLVII AND XLVIII BY CALCULATING MEANS FOR EACH COLUMN SEPARATELY)

SEAT-HEIGHT (C)	ELBOW-HEIGHT (A)	DIFFERENCE (A − C)	RATIO OF A TO C	NUMBER OF CASES
9.375	17.45	8.08	1.85	63
10.375	18.04	7.66	1.74	250
11.375	19.10	7.72	1.68	370
12.375	20.20	7.83	1.63	349
13.375	21.42	8.04	1.60	275
14.375	22.85	8.48	1.59	381
15.375	24.38	9.00	1.58	653
16.375	25.54	9.16	1.56	588
17.375	26.58	9.20	1.53	289
18.375	27.81	9.43	1.51	121
19.375	28.75	9.37	1.48	19
20	29.38	9.38	1.47	4
14.404	22.956	8.77	1.59	3362

the knees are from the floor; but the longer the arms, the lower the elbows are from the shoulders. There are long-limbed types with short bodies and short-limbed types with long bodies, as well as those that are long, short, or medium in both respects. Thus it is that tall high-school pupils often have their elbows nearer the seat level than do some little first-graders.

Table XLIX shows the data of Tables XLVII and XLVIII combined for more convenient comparison of the averages for each seat-height group. Omitting the first and the last two groups, because the number of cases included is too small for averages to be reliable, we note that there is a quite regular increase of the difference and a correspondingly regular decrease of the ratio between elbow-height and seat-height. But an increase of 8 inches in seat-height corresponds to a total increase of only 1.77 inches in difference, an increase of but .22 inch in difference per inch of seat-height increase; while at every seat-height there is a variation of 6 or 8 inches in difference among individuals of the group.

The conclusion from the figures, therefore, is that the desk-height (so far as may be judged from the elbow-height) cannot be safely determined from the seat-height; and that instead of a fixed ratio between these two heights, what is required is a desk top which is adjustable with reference to the seat. There are, however, other facts which must be taken into consideration.

Leg space under the desk. The great majority of school desks are provided with book boxes or shelves under the top, the total depth of which is seldom less than six inches and often as much as eight. There must be room enough between the bottom of the book box and the seat for the pupil's thighs. These thighs range from three to eight inches in thickness, including only ordinary school

clothing and making no allowance for cloaks, overcoats, the usual contents of boys' pockets, or for any movement whatever. There is, therefore, a physical necessity for a difference of from ten to sixteen inches between seat and desk surface in the case of desks having these book boxes. Even more is necessary if the boxes are deep and if fleshy pupils are to get their legs under them in comfort.

There must be clearance for the knees under the book box, and these are often five and occasionally six inches higher than the seat. If the desks are not adjustable, the knee space must be sufficient for the highest knees of all those who are to occupy it, for the tall knees cannot get under a shelf which is merely high enough for the average. But the knee-height for some individuals in every seat-height group is greater than the elbow-height for some others; and when we add to this maximum knee-height from seven to ten inches for book box and necessary movement of the legs, the top of the desk is almost up to the shoulders of some who are expected to use it. Space under the desk can sometimes be provided for fleshy thighs by lowering the seat, but knee space must be provided for by elevating the desk.

Not only are the knees and thighs of some individuals of every group as high as are the elbows of others, but there are many whose elbows are but two or three inches higher than their own knees or thighs. Hence it is quite certain that however the desks are adjusted, so long as book boxes are six or eight inches deep the tops will be too high for a large proportion of the pupils. The most necessary step toward securing proper desk-height, therefore, is to eliminate the book box or to make it as shallow as possible. It will be seen later that the correct writing-height is actually from two to four inches higher

than the measured elbow-height, and a careful study of the figures indicates that if the depth of the box can be kept within four or five inches, the great majority of pupils can be properly accommodated by setting the boxes as low as the maximum knee-height for each group permits. All can be suitably provided for if the boxes are shallow and desks are adjustable.

Table LII, on page 204, is to be interpreted as follows (using the 16-inch seat-height group for illustration): The mean seat-height of this group is 16.375 inches (range 16 to 16¾) and the mean elbow-height is 25.54 inches (range 22 to 28, as shown in Table XLVII), which gives a mean difference-measure of 9.16 inches (range 6 to 12, as shown in Table XLVIII). But there are individuals included who require a clearance of 22.5 inches from the floor under the desk for their knees, which is greater than the elbow-height of some and but 3 inches less than the mean elbow-height for the group; and there are individuals who require 7 inches clearance between the seat and bottom of the desk for their thighs, which is more than the difference-measure for some and but 2.16 inches less than the mean difference-measure for the group.

The measurements upon which the statements of this section are based are shown in Tables L–LII. As would be expected, the maximum as well as the mean knee-height increases regularly with the seat-height, as do the mean difference and mean thigh-thickness. But the maximum thigh-thickness is found in the groups with seat-height from twelve to fourteen inches, which confirms the statement made elsewhere that stout pupils have lower seat-height measure than would be anticipated from their size.

The method of taking these measures is explained in Chapter X and illustrated in Fig. 29.

TABLE L. CORRELATION BETWEEN SEAT-HEIGHT AND THICKNESS OF THIGH MEASURED FROM SEAT AT ABDOMEN

Note. Add .375 to head of each column and row for true value of interval.

SEAT-HEIGHT IN INCHES	THICKNESS OF THIGH IN INCHES						TOTAL	MEAN (INCHES)
	3	4	5	6	7	8		
9 . .	3	1					4	3.62
10 . .	11	22	2				35	4.12
11 . .	22	58	9				89	4.23
12 . .	8	120	42	1		1	172	4.61
13 . .		126	79	11	1	1	218	4.87
14 . .		43	125	27	7	1	203	5.38
15 . .		33	135	75	5		248	5.59
16 . .		7	140	90	11		248	5.80
17 . .		2	100	68	3		173	5.79
18 . .			49	49	3		101	5.92
19 . .			13	4			17	5.61
20 . .			3	1			4	5.73
Totals	44	412	697	326	30	3	1512	5.306

TABLE LI. DISTRIBUTION OF KNEE-HEIGHT (MEASURED FROM SEAT) AND MAXIMUM KNEE-HEIGHT FOR THE GROUP (MEASURED FROM FLOOR) FOR EACH SEAT-HEIGHT INTERVAL

Note. Add .375 to head of each column and row for true value of interval.

SEAT-HEIGHT (C) IN INCHES	KNEE-HEIGHT IN INCHES						TOTALS	MAXIMUM HEIGHT FROM FLOOR
	1	2	3	4	5	6		
9 . .	1	1	2				4	13.5
10 . .		24	10	1			35	15.5
11 . .	1	38	44	6			89	16.5
12 . .		58	107	7			172	17.5
13 . .		51	141	24	2		218	19.5
14 . .		18	135	44	5	1	203	21.5
15 . .		4	138	93	13		248	21.5
16 . .		3	82	141	22		248	22.5
17 . .			48	108	16	1	173	24.5
18 . .			19	69	13		101	24.5
19 . .			2	12	3		17	25.5
20 . .				3	1		4	26.5
Totals	2	197	728	508	75	2	1512	

TABLE LII. MEAN ELBOW-HEIGHT, MAXIMUM KNEE-HEIGHT FROM FLOOR, MEAN DIFFERENCE BETWEEN SEAT-HEIGHT AND ELBOW-HEIGHT, AND MEAN AND MAXIMUM THIGH-THICKNESS FROM SEAT, FOR EACH SEAT-HEIGHT INTERVAL, SUMMARIZED FOR COMPARISON FROM TABLES XLIX, L, AND LI

SEAT-HEIGHT	ELBOW-HEIGHT	MAXIMUM KNEE-HEIGHT FROM FLOOR	MEAN DIFFERENCE (A − C)	THIGH-THICKNESS FROM SEAT	
				Mean	Maximum
Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
9.375	17.45	13.5	8.08	3.62	4.75
10.375	18.04	15.5	7.66	4.12	5.00
11.375	19.10	16.5	7.72	4.23	5.00
12.375	20.20	17.5	7.83	4.61	8.00
13.375	21.42	19.5	8.04	4.87	8.00
14.375	22.85	21.5	8.48	5.38	8.00
15.375	24.38	21.5	9.00	5.59	7.00
16.375	25.54	22.5	9.16	5.80	7.00
17.375	26.58	24.5	9.20	5.79	7.00
18.375	27.81	24.5	9.43	5.92	7.00
19.375	28.75	25.5	9.37	5.61	6.00
20.375	29.38	26.5	9.38	5.73	6.00

Adjustment range. An important fact disclosed by the figures and observations of this section is that the *range* of adjustment provided in adjustable equipment is effective only so far as it provides for the depth of book box and thighs. For example, if the box construction consumes 7 inches, and 7 more are allowed for thighs and movement, no adjustment at all is available in a desk which adjusts from 24 to 30 inches with a seat which adjusts from 16 to 20 inches, since the seat must be at the lowest adjustment, and the desk at the highest, to be used at all. If the box depth were reduced 2 inches and the seat range lowered 2 inches (14 to 18), the entire seat and desk range would be available.

Results of statistical studies. To sum up the chapter thus far, we may say that the innumerable statistical investigations which have been devoted to the problem of desk-height during the past century, instead of giving

us a rule-of-thumb based on numerical averages, have definitely shown that no such handy rule or ratio is possible. There is no fixed relationship between proper desk-height and either the stature or the seat-height of all pupils, varying as they do in segmental proportions. Limiting factors and general principles which are equally important for the final solution of our problem have been presented. Having reached this conclusion, we are free to proceed more constructively to determine just what the correct position of the desk top for each individual is.

Correct position of the desk top. Since writing must be done on the desk surface while books may be variously held for reading, it is agreed that the most essential desk position is that which is most favorable for writing in erect posture, without eyestrain, and with the maximum freedom and ease of writing-movement. This position may be described as that in which, when both elbows are brought slightly forward and not more than about three inches from the sides, the forearms lie symmetrically in the plane of the writing-surface at approximately right angles to each other, resting lightly on the muscles under the forearms so as to move and pivot freely on these muscles, the elbows bent at approximately right angles. The precise angle of the elbow bend is unimportant and will vary with the slope of the writing-surface.

In this position a too flat surface will give an excessive visual distance and foreshortening which the pupil tends to correct by stooping over the desk and sacrificing the posture described, while a too great slope is fatiguing to the arms and causes papers and other objects to slide off the desk. The usual slope of from ten to fifteen degrees is a compromise with these last-mentioned

practical considerations and is as low as should be permitted. A somewhat greater slope would be better hygienically.

The reason for having both arms rest on the desk is that this avoids lateral curvature and twist of the spine (compare Figs. 12–14) and at the same time permits the left hand to hold the paper in place.

In order to hold the forearms at right angles to each other, it is necessary to extend the elbows *slightly* outward sidewise, but if this lateral extension increases beyond two or three inches the shoulders are drawn forward, compressing the chest and destroying the erect poise of the body upon the spine. As the elbows are drawn out and forward they are elevated, which necessitates the elevation of the writing-surface and, by bringing the shoulders up and forward, causes the back to stoop. The pupil then, of necessity, rests his weight upon his arms on the desk.

When one writes in the approved position described above, the movement control is almost exclusively in the muscles of the upper arm; the muscles under the forearm (which control wrist and finger movements) function as a cushion on which the arm moves to form the letters and as a pivot about which the hand moves along the lines. This is the so-called "free-arm movement," which may be supplemented slightly by wrist and finger control in the "combined movement."

The elbow is strictly a hinge joint, permitting the forearm to move only in the same plane as the upper arm, and the hand to move only in an arc to and from the shoulder. Hence when the elbow is kept low, its angle does not change nor function in the writing-movements. Any change in the elbow angle could serve only to lift the hand from the desk or to push it down through it. The elbow does not rest upon the desk, but rests about two to four inches behind it, and the movement of the upper arm pivots the forearm about the muscular cushion as the hand moves along the lines. If the elbow itself bears on the desk, then it becomes the pivot, and the muscle and forearm must be dragged over the surface.

When the elbow is extended outward on a high desk, the writing-movement is radically changed. The forearm cannot

pivot on the muscle, because the distance of the elbow from the side is now fixed by the length of the upper arm. The lateral movements of the hand must be from the elbow joint; but as this joint is a hinge only and the forearm can move only in the same plane as the upper arm, the pupil tends to lower his shoulder into approximately the plane of the desk top to secure a free movement of the hand along the lines. Thus a high desk very positively causes a lowering of the shoulders, and this not only involves stoop but brings the eyes very close to the paper — too close for clear vision. The pupil tends to correct the visual difficulty by twisting his neck to the left. The result is a posture approximating that shown in Fig. 10, p. 44.

It is a recognized principle that the learning of muscular coördinations proceeds "from fundamental to accessory"; that is, the larger basic movements are first acquired, and these are refined by supplementing them with the development of the finer detailed movements. In the reverse process it is inevitable that the minute detail movements will have to be relearned in a new setting at best, and will probably have to be unlearned before coördination with larger fundamental but later-acquired movements is possible.

Because of the principle just stated, modern teaching of writing begins with the development of the fundamental arm movements rather than with precision in the formation of letters. Coarse pencils or crayons are used and characters are made large so as to require arm rather than finger movements. Finger movements, being distinctly of the accessory sort, are developed, if at all, supplementary to and never prior to the arm movements. Therefore desks for little children just learning to write should be most favorable to this free movement poised on the muscle under the forearm. Not that there will be any early insistence upon a precise "correct position," but that the natural convenience and efficiency of this position (which is the reason that it is "correct") may be early discovered and utilized by the child. Any height or slope of desk which makes this easy poise and movement difficult unquestionably complicates the task and increases the burden of learning to write.

Range of correct writing-positions. An examination of Fig. 36 will make it clear that there is a variety of positions of the writing-surface which meet the general conditions that we have stated and are suitable for a given individual with a fixed seat and elbow-height. These positions, however, are subject to quite definite limiting principles. Each position is a combination of a certain height, slope, and spacing, and no one of these factors can be changed without a corresponding change of the other two. Height, slope, and spacing are always interdependent factors in desk position.

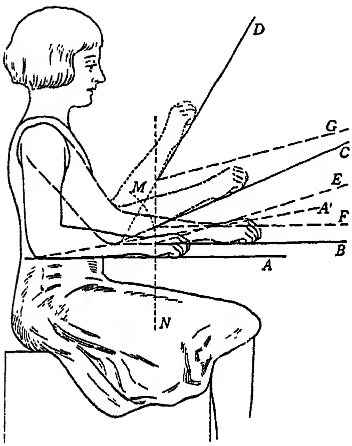


FIG. 36. Relation of several positions of the writing-surface to the elbow-height

Position A is that of a tablet arm as ordinarily used in tablet-arm chairs (see Fig. 37). Obviously it can neither be raised nor lowered without involving an uneven height of the two shoulders and a lateral bend of the spine; hence it should be at precisely the elbow-height. In the position of the hand shown the visual distance is usually too great, and a sharp bend of the neck is almost inevitable. If the elbow is moved forward on A, the visual distance is increased still more, and to keep the forearm on the desk the shoulder must be lowered by bending forward, which will probably involve stoop. If, however, the tablet arm is somewhat sloped, as in A′, the visual

distance and angle are improved and the elbow may be advanced without stooping.

At best a tablet-arm surface is at one side instead of squarely in front of the body, and hence its use involves a side twist of shoulders and neck. It is also in the shadow of the body when light comes, as it should, from the left rear. For these reasons it is unhygienic for continuous writing or study. Because of the compactness and convenience of this type of equipment it is extensively used in colleges and increasingly so in high schools. If used only for lecture purposes, in which writing is merely incidental and confined mostly to taking occasional notes, it is unobjectionable, but its general adoption for study and classroom purposes should be strenuously opposed.

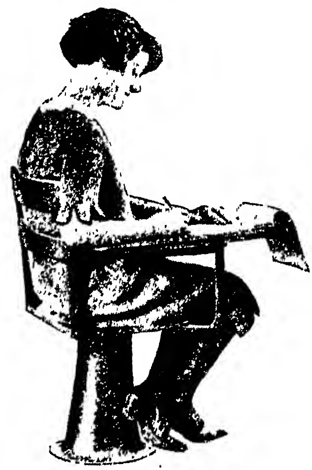


FIG. 37. Tablet-arm chair, pedestal type. Suitable for lecture rooms, but not for continuous study or writing

For any full-sized writing-surface in front of the body the elbows are advanced nearly to the desk edge and approximately to the line of the front of the body. With elbows kept close to the sides, this advance involves a minimum of muscular effort, since the upper arm merely swings forward like a pendulum, practically as it does in walking; but as the elbow advances, the pupil remaining erect, it is elevated. Hence the height of a desk in front of the body should be a few inches greater than the elbow-height as measured.

The amount of this increase of height depends on the distance that the elbow is moved forward. It depends also on the length of the upper arm, since a short pendulum is raised more than a long one in the same amount of forward swing. Therefore the greater the spacing of the desk from the chair the higher the desk must be, and the shorter the forearm the higher the desk must be at the same spacing.

Now, with the elbow advanced as shown in Fig. 36, a level-top desk, as in position B, must be at the height of the elbow. If higher, as in F, the elbow would have to be elevated sidewise to get the hand on its surface; but if sloped, as in C, it would be at the same height (at near edge) as F without changing the position of the elbow. This position (C) also affords a much better visual distance and angle and an elbow angle more favorable to muscular control than the very large angle necessary for writing on B. But if the desk had the slope of C and the height of B (at near edge), both hand and elbow could not lie in its plane unless the pupil stooped far forward to lower his shoulders. Similarly, it is quite possible to write in an erect position with the desk at a much greater height and slope, as in D (though this is inconvenient for other reasons); but a less slope at this height, as in G, would necessitate elevating the elbow far out from the side and lowering the shoulder almost to the same plane.

In general, then, the greater the slope of the desk the higher it should be, and vice versa. The more distant the desk, the more the elbow is advanced and raised, and the higher the desk should be; but the more the desk is raised for the same position of the elbow, the more the forearm is brought toward the shoulder, and hence the more the desk should be sloped and brought nearer.

Usually the slope of the top is fixed, and the only problem is one of height adjustment. The rule is simple: *when the pupil is erect, with arms in writing-position, the desk top should be in the plane of the underside of the fore-arms.* The flat-top desk must be very low, and sloped desks should be higher in proportion to the slope.

If the top is adjustable in two or three respects independently, the right combination is complex and difficult to attain. No rule can be given, and the correct adjustment is a matter of trial.

Finally, a very high degree of precision in desk adjustment is neither practicable nor necessary. The pupil automatically adjusts himself to the desk, and this is unobjectionable *so long as he remains in erect position,* with shoulders well back and down.

Desk-top requirements for reading. The desk surface is probably used more for a book rest in reading and study than it is used for writing. Furthermore, the educational trend is unquestionably toward a great increase in the amount of reading required and correspondingly less of writing. The time may not be far distant when penmanship will become a relatively minor school activity and furniture will be designed primarily for reading and typewriting rather than for handwriting; but at present desks are designed almost exclusively for writing, and the requirements for correct posture in reading are practically ignored, the assumption being that one must write on the desk but may hold his book for reading in any position desired.

As stated in Chapter VII, the position of the book in reading is probably more important for both posture and vision than is that of the desk surface in writing. The visual discriminations required for reading are much

finer, the eye movements much more rapid, and the strains of optical convergence and accommodation more serious. Certainly visual defects are brought about far more by reading than by writing. Postural compromises are constantly made to meet the insistent demands for relief from eyestrain and lack of visual clarity. Pupils lay their books on the desk and stoop far over to secure a visual angle and distance which make the print legible. They stand their books on end and slide down under the desk to get their eyes level with the pages. To get their eyes within range of the books, they resort to neck bends, spinal twists, resting of the head on hands or arms with elbows on desks or knees or backs of seats, and innumerable other contortions. What they will not do (for more than a moment) is that theoretically correct thing of sitting erect and holding the book at the ideal height, slope, and distance. The reason is that they cannot so hold it without acutely painful fatigue of the arms.

Since the desk is inevitably used as a book rest, it must be made a good one before the problem can be regarded as solved. The proper position of a book for reading is at right angles to the line of vision as one sits erect, approximately sixteen inches from the eyes (varying with type, light, and focal distance of the individual). This means that it should be at the height of the chest or chin and at a slope of forty-five degrees or more. But a desk top in this position is at the highest possible, and usually impracticable, writing slope. Hence a desk for both reading and writing must have an adjustable top, and it must be adjustable for a very wide difference of positions. Mere indefinite adjustability, so far from accomplishing the two purposes, is more likely to defeat both. There is a very limited range of right positions for either writing

or reading and an unlimited number of wrong ones. There is no instinctive or natural tendency for the pupil to select the right positions. The problem is to construct a top which can be correctly placed for either reading or writing and nowhere else. And this change of position must be easy, silent, and instantaneous.

There have been various "adjustable tops" and "reading tops" devised for the purpose. Some of them cannot by any means be correctly placed for either reading or writing. Some of them are right for one but not for the other. Some of them can be placed so variously that the chance of correct position is slight. Few of them are mechanically practicable for successful schoolroom use.

It is, of course, no solution merely to tilt the book or stand it on end, unless height, distance, and slope are right. It is also no solution to provide adjustments in the three respects independently, with no assurance that the combination of them will not be worse than no adjustment. The problem will be considered further at the close of the following chapter.

CHAPTER XVI

ADJUSTABLE FURNITURE

A story of neglect. An article in an educational journal intended as an appeal for the use of adjustable seating was illustrated by a photograph of a schoolroom showing the bad posture resulting from misfit furniture. It happened that the very furniture shown in the photograph was adjustable, though not adjusted.

The writer visited a city widely known for its excellent schools and their interest in seating equipment. The name of that city is used to distinguish seating plans which originated there and school desks which are manufactured there. In one classroom he ventured to call attention to numerous pupils whose seats were so high that their feet could not touch the floor. The teacher joined in deploring the hygienic injury to which they were being subjected. When it was suggested that the difficulty could be remedied in a short time by the use of a wrench, she insisted that the desks were not adjustable — the janitor had said so. A demonstration was necessary to convince her that every desk in the room was adjustable. Superior officers who were consulted confessed that they did not know whether or not their equipment was adjustable. Unadjusted adjustable seating is in general use throughout this city, as it is in innumerable others. Seldom is there any systematic plan or definitely placed responsibility for getting the adjusting done. Principals, teachers, medical inspectors, school

nurses, physical-training directors, and supervisors are mentioned as having charge of this matter, but seem usually to be unaware of the fact or to have delegated the responsibility to someone else. Ultimately it generally falls upon the janitor, if anywhere, and he refuses to include it among his duties, does not know how, or has lost the wrench. In one large city the union forbids the janitors to do this work, and no other mechanics are available for the purpose. Whatever the reason or lack of reason, desks are rarely adjusted. Many children sit the year through on adjustable seats with their heels unable to touch the floor.

It is by no means uncommon to find rooms equipped with adjustable seats and desks all carefully set at the same height for the sake of uniformity in appearance!

In the exceptional cases where provision is definitely made for getting the adjusting done, the methods pursued are frequently such that only extreme misfits are avoided and the large majority of seats are set too high for the occupants. In one superior school with unlimited supervisory and mechanical service available the principal says frankly that adjustment has accomplished so little in getting better seating conditions that it has been practically abandoned in his school.

School surveys have seldom done more than to report the proportion of desks that were nonadjustable and to assert that they ought to be adjustable. In the Denver survey of 1916 we read that of more than six hundred classrooms only sixty-nine had adjustable desks. In only 12 per cent of these had they been adjusted within the half-year, in 11 per cent they had not been adjusted for a year, in 32 per cent they had not been adjusted for from one to three years, and in 37 per cent they had

never been adjusted. It is doubtful if many cities could make as good a showing. The New York State survey reported that from 51.1 per cent to 67.4 per cent of the seats inspected were improperly adjusted. The Ohio survey reported more than 40 per cent of the pupils as sitting with seats so high that their feet were dangling; but these data include nonadjustable seating.

A story of reaction. Under such conditions it is not surprising that many leading educators are frankly advocating nonadjustable seating. Without precise data on the subject it is the writer's impression that classrooms equipped with a *proper assortment of sizes* of nonadjustable seats usually have the pupils better seated in respect to size than do those in which adjustable equipment is provided. The spread of platoon and departmental organization also militates against all plans of adjustment.

The "fitting" fallacy. The conclusion is almost inescapable that adjustable seating as a means of fitting the furniture to the pupils is a failure. Either a far better and more widely disseminated knowledge of how to fit seats and desks to pupils and an effective plan for getting this done must be developed or the pretense should be abandoned. School hygienists have insisted that seats and desks should be adjusted to pupils twice a year in order to keep pace with their growth. The fact is that most children would have to grow some inches before the seats as now adjusted would fit them properly, for, as we have seen, the important thing is not that the seat should "fit" the pupil but that it should not be too large for him.

Economy in distribution. The value of adjustable seating lies not so much in this futile attempt to keep pupils

fitted as in the simplification of the problem of selection and distribution of equipment. As previously indicated, at least three sizes of nonadjustable desks are required for every grade room, but one size of adjustables of properly determined range is adequate. Any desired assortment

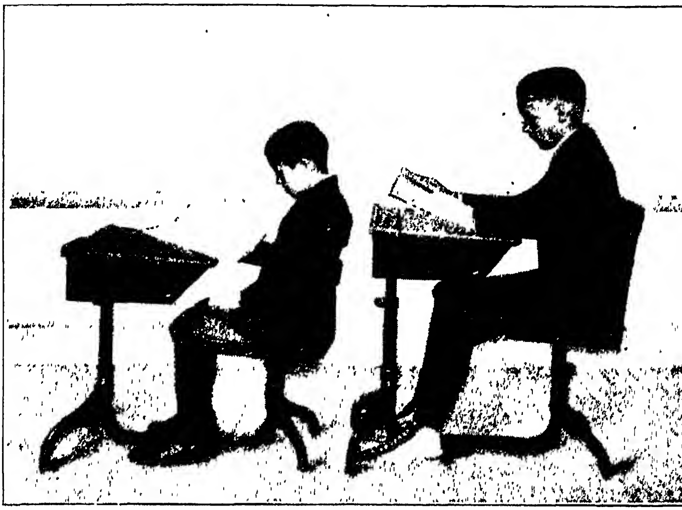


FIG. 38. Adjustable desks of the same size equally adapted for classmates differing more than a foot in stature. Tubular-steel movable desk with swivel chair and lifting-lid book box. (Ohio University Training School)

of sizes and any change of assortment as may be required from time to time are available at the cost of a few minutes' work with a wrench. Pupils may be shifted from one part of the room to another regardless of size and as dictated by instructional and disciplinary considerations. The varying assortments of pupil sizes from term to term are provided for, and classes may interchange rooms without transfer of furniture. There need

be no waste or delay incurred by having a surplus of seats of some sizes or an unforeseen shortage of others, nor the expensive labor of exchanging them. Furthermore, equipment, like the buildings, should be provided with reference to possible future needs as well as present needs, and the adjustable feature provides for the possible development of adequate knowledge and methods of the most precise adjustment to individual size.

Precision in adjustment. In adjusting seats and desks to individual needs it is a mistake to attempt too great precision. A quarter inch or half inch in any dimension is meaningless. A seat within a quarter inch of the greatest permissible height is already too high and should be lowered half an inch on general principles. If reasonably well shaped, it may be two inches lower without disadvantage. So far as desk-height is concerned, no one knows what correct height is within an inch or more. Momentary changes of position or occupation justify considerably greater changes from the theoretically correct height.

Method of adjusting. The equipment should be set at the approximately correct assortment of heights at the time of installation. Table XIV, Chapter XII, affords a safe guide for this preliminary setting. As with any other structure or machine using bolts, some of these will probably work loose during the first few days of jolts and strains on account of minute irregularities of threads on the bolts, or of metal surfaces, enamel, etc. Some of the adjustments may slip quite out of place. Any mechanic knows that bolts must be retightened after a period of use before they can be regarded as permanently tight. Meanwhile the teacher will have found some changes necessary to provide for the desired placing of

the pupils about the room. The proper seat-height for each child is carefully checked according to the very simple rule that *there must be no pressure from the forward part of the seat against the popliteal area behind the knees.* Desk-height is checked to see that when the pupil is seated erect, with arms in writing-position and elbows close to the sides, the muscles under the forearms rest firmly on the surface of the desk or as near to this position as possible, with provision for free movement of the knees under the desk. If the majority of the class have been assigned to seats according to size, it will be found that relatively few changes in adjustment will be required. Necessary changes can be indicated on slips placed on the desks, and adjustments made under the supervision of the teacher or supervisor who is directing them. This will require but a short time at recess or after school. Within a day or two all adjustments should be verified for the entire class and further changes made if any are advisable. Then every bolt should be carefully tightened. Nothing more should be necessary for the year or half year that the same class occupies the room, but the process should be repeated for each new class.

Where seat and desk adjust independently of each other, as is usually the case, it should be noted that if the seat is set too high relative to the desk the restriction of leg room leads the pupil to think that the desk and seat are too small for him. The writer has found many pupils complaining of their desks being too small and has afforded relief by lowering the seats. Likewise, if the desk is too high, the pupil may get the impression that the seat is too low. The only safe guide is, as already indicated, to set the seat low enough to avoid any pressure under the knees or from the forward edge of the seat and

then to lower the desk to the best writing-height, or as near it as will allow adequate knee room. Lowering the seat, however, does not reduce the knee-height; and where book-storage space is deep, it is sometimes necessary to set the seat higher than it should be to get a practical relation between seat and desk-height. This is a defect which can be overcome only by making book boxes shallower.

The actual labor of adjusting may profitably be performed by larger boys as a manual-training project. Care must be exercised, however, to warn them against stripping threads or breaking castings by overstraining. It is also important, where nuts are to be manipulated at both ends of the furniture simultaneously, that both are loosened or tightened about equally at all times and that one is not made tight while the other is very loose. Moreover the seat or desk should be kept level during the adjustment, otherwise the twisting may break or bend the frame or adjusting mechanism. In resetting, care must be taken to see that seat or top is perfectly level. A yardstick is a convenient gauge for this purpose and is much safer than any guess or sighting.

The necessity of keeping adjusted. These adjustments should not be — and in most cases are not — very easily made. Usually a special wrench is necessary to make them expeditiously. The reason for this is that a nut which is easily loosened is a temptation for the meddlesome proclivities of mechanically minded youths. Unfortunately the special wrench is often misplaced, and the tightening of loose nuts or the making of desired adjustments is indefinitely postponed and ultimately forgotten while the custodian is vaguely waiting "for the wrench to turn up" or to find out where he can get

another one. One writer referring to this characteristic loss of the wrench describes it as "much as though fire escapes had been provided at great expense, and then the doors leading to them securely locked and the keys lost." The wrench should be the special responsibility of somebody, it should be always accessible, and it should be used promptly when needed. Loose bolts inevitably mean wabbly or squeaky furniture and rapid deterioration of the equipment.

Comfort as a criterion. The criterion of correct adjusment is not that it "feels comfortable" to the pupil, which is a test very often used. It is a peculiar fact that pupils who are allowed to determine their seat-height by the "feel" will almost invariably make it too high. This appears to be due to the fact that there is a temporarily comfortable feeling of "fit" in a seat which presses firmly along the whole length of the thigh, including the nerves behind the knees. But the very pressures which make a seat feel comfortable when one sinks into it to try it (especially after he has been on his feet for some time) are largely those which make it uncomfortable and injurious when occupied for a long time. A mere change from one seat to another will ordinarily afford a momentary comfort, although the latter may be a table top or a rail. Unless he has been made conscious of the factors which make for permanent comfort, a child will often select as more comfortable a seat so high that his feet cannot touch the floor rather than one that is correct for his size. Children are extremely suggestible in this respect, and most of them will say exactly what they think is expected of them. The writer has secured many very valuable suggestions from children as to the specific elements which make a particular type of seat comfortable

or uncomfortable; at the same time he has been able to lead them by suggestion into almost any opinions desired. Even the "feel" that a seat has for a mature and careful analyst of his own sensations is no safe guide, because a most unhygienic slump or contortion may be momentarily far more comfortable than an erect position, particularly for one whose habitual posture is bad. Unless controlled by adequate knowledge and wisely developed habit, one's likes and dislikes are no more a safe guide for his seating than they are for his eating. A little instruction, however, will soon make a pupil intelligently conscious of the factors which indicate that a seat or desk is too high or of other elements in seat or back which make erect posture difficult.

Other criteria. The fallacy of using as the correct seat-height any fixed ratio to the standing-height has been shown. The ratio of 25 per cent may be used for a tentative setting, with the probability that very few will be raised and a considerable proportion lowered in the final adjustment. Godin recommends setting the seats at the height of the tuberosity of the tibia as felt on the outer side of the knee, but this does not allow for varying flesh conditions. Nor is any measure of the lower leg reliable, however taken, unless taken when the person is actually seated in the type of seat to be adjusted. Gauges which manufacturers supply with the seats are more reliable, but a large margin of error arises from the way the pupil is sitting when measured, the height and kind of seat on which he is sitting, and the differences in results arising from the way different individuals use the gauge. Altogether, the simplest and best method seems to be to set the furniture originally according to the tables given in Chapter XII, and

thereafter to check, recheck, and make adjustments as described in the preceding pages.

Adjustable desk tops. The ideal position of the desk top has been discussed in Chapter XV and as a problem of vision in Chapter VII. The conclusion is that, aside from differences among individuals, the best position of the top for any one individual is not the same for all occupations, that an ideal writing-surface is not a proper position for a book rest for reading. Because of this fact numerous devices have been used from time to time with a view to making the desk top readily convertible for all purposes. There have been many variations of sliding tops and tilting tops and those which turn back by means of some hinge or pivot arrangement to provide a book rest for reading. Accessory book rests capable of all sorts of adjustment have been devised and patented in great numbers. Many of the recently developed chair-desks have sliding, tilting, lifting, and other adjusting devices for the desk surfaces, which are supported from the movable chair base. A fundamental difference between such adjustments and those previously discussed in this chapter is that these are all intended to be made from moment to moment by the pupil instead of only at long intervals by supervisory authority. To be effective, therefore, they must be made quickly, easily, and silently by the pupil without disturbing his classmates or seriously interrupting his own work. In the main these devices have failed to win general and permanent approval for one or more of the following reasons: (1) the adjusting mechanisms are too complex or too fragile to stand the hard usage of the schoolroom; (2) they soon become loose, noisy, insecure, and otherwise annoying; (3) they are, or are regarded as, a temptation to children to play

with the mechanisms and add to disciplinary troubles; (4) hands or clothing may be caught and injured in the moving parts; (5) some of the adjustments require the control or assistance of the teacher, or the use of a wrench or other implement, or at least the rising of the pupil from his seat with disturbance of the class and distraction of his own attention; (6) the range of adjustment is frequently inadequate to secure the positions which are practically or hygienically desirable; (7) the range of possible adjustments is so indefinite that pupils are unable to select the precise movement or combination which insures the postural or educational effects intended; (8) two or three quite independent adjustments (that is, for height, slope, and tilt) are required, with no assurance that the combination attained will be effective for the purpose intended or will not be worse than if no adjustment were made.

Unless it is practically assured that the new position will be better than that of a fixed top, there is no advantage and there may be serious disadvantage in the adjustment feature. The number of possible bad positions is far greater than the number of correct ones, and the chance that a pupil will select the right one out of a large number of wrong ones is but slight. Unless he has been carefully trained, his judgment here is an even poorer criterion than in the simpler matter of height adjustments. Neither teachers nor makers of desks have yet developed a clear knowledge of all the factors involved in the correct placing of the desk surface for one individual engaged in a single occupation, much less for all who are to occupy the desk and all occupations in which they are to be employed. So far as the writer is aware no one has yet attempted to or has been competent to

train children systematically in the proper use of adjustable desk tops, nor have tops been available for proper adjustment. Many of the so-called reading desks can by no possible means be set in a position which is hygienically proper for that purpose. The fundamental aim of this type of adjustment, however, is essentially sound, and criticism should serve to stimulate rather than discourage effort. Meanwhile adjustable desk tops should be regarded with skepticism as to the practical or hygienic claims made for them. It may be said in the light of the many attempts which have been made, that no such device will be successful unless it is possible for the pupil to change it from one useful position to another with a single easy and silent movement, without rising or disturbing others, with a certainty that the resulting position will be correct hygienically and that the device is rigid, durable, sanitary, safe, and as fool-proof as successful school desks must always be. When a reading top which effectively meets these ideals is available, it will be a tremendously important contribution to visual and postural hygiene as well as to educational efficiency.

CHAPTER XVII

MOVABLE SEATING

Movable seating not an innovation. The screwing of school seats to the floor is not a time-honored and universal custom, nor are movable seats a modern American device, as many seem to think. The reverse is nearer the truth. Early crude furniture was sometimes built to the floors, but the deliberate screwing of it down to keep it in alignment is a part of the excessive rigidity which developed in American schools during the past century. European writers criticize the custom as the "American plan." Dufestel, medical inspector of schools in Paris, writes in "Hygiène Scolaire":

> The hygienist demands that the daily cleaning under all parts of the desk shall be possible. The French regulations forbid the fastening of desks to the floor so as to render them immovable. Hygiene cannot but denounce this practice because dust accumulates under the supports and foot rests and is difficult to dislodge therefrom. It is desirable that furniture shall be easily moved in order to facilitate cleaning.

So necessary is mobility considered that European desks are frequently built on individual platforms which move with the desks, or several desks are attached to a pair of heavy strips which slide on the floor. Even this is objected to by Eulenberg and Bach, leading German authorities, who state bluntly at the beginning of their discussion of seating: "The attachment of several school desks together is entirely impracticable and seriously

interferes with the sanitation of the schoolroom. Each seat and desk should form an independent [movable] unit in itself."

Sanitation and floor preservation. It cannot be denied that thorough cleaning about stationary desks is almost impossible, nor that the usual sweeping is very far from being thorough. Scrubbing is particularly difficult, the dirt-thickened water lodging about the feet of the standards and frequently working into the screw holes to soften the wood and loosen the hold of the screws. There are from three hundred and twenty to eight hundred screws used in a standard classroom installation, and when any or all of these desks are rearranged (which probably occurs sooner or later) the holes remain as unsightly catchers of dirt and centers of decay. The increasing use of fine hardwood, concrete, composition, or linoleum-covered floors makes the destructive practice of screwing down furniture more and more deplorable and extravagant. There are economies in the use of stationary seating, but against these must be charged the injury to floors and a high cost of cleaning if the cleaning is to be thorough. Janitors will usually maintain that it is much cheaper to sweep a floor with stationary furniture than to have to move and rearrange the desks, and this is true if we are content with that sort of sweeping.

An important economy in janitor service is possible and better cleaning is assured by having the children move their desks to the sides of the room at the close of the school day. At dismissal each pupil slides his desk to a designated position, so that all the desks are massed solidly in the side aisle spaces and in the open area at the front of the room. The janitor then sweeps the cleared space where the desks belong, replaces them and sweeps the

remaining spaces with even less effort than is necessary for working effectively around the feet of stationary seating. One superintendent reports that he saves the time of one janitor in each medium-sized building by this coöperation of the pupils. More thorough sweeping undoubtedly results. To avoid confusion, however, it is necessary that forethought and some training of both pupils and janitors be devoted to developing an inviolable routine of moving and replacing desks. The plan should involve minimum distances and unequivocal placing. In a typical straight-line arrangement of five rows, the following is found effective: Rows one and five push their desks directly against the adjacent walls and, as they pass into line for dismissal, rows two and four move their desks against those of one and five. Meanwhile row three has moved theirs into compact formation at the front of the room. If the teacher's desk is in front of row three, the movements of this row and either two or four are interchanged. In the "quadrant plan" all desks are moved into solid formation, maintaining integrity of the rows, in the open area at front of the room. There are disciplinary and training advantages in having janitor and pupils work out the most effective movement in coöperation.

Building and equipment economies. A large part of the rapidly increasing cost of school-building is ascribable to the growing demand for "special rooms" of various kinds equipped otherwise than with regular classroom furniture. In many schools these special rooms are occupied but a small proportion of the time, thereby seriously increasing the housing costs. Movable equipment makes possible the use of such rooms for various purposes, thus increasing facilities and economizing in

building costs. Any regular classroom may be quickly adapted for play, dancing, physical exercises, social activities, mothers' meetings, community gatherings, evening classes, and other purposes by the shifting of furniture. While some such adaptation is often made, no architect or administrator seems as yet to have made a systematic study of the economy in building and increase of facilities possible to the use of movable equipment. Administrative policy in a growing school system will often require the shifting of grades or departments from room to room or from building to building. The convenience and economy of movable seating in such cases is obvious. Changes in the number of pupils in a class or department are constantly occurring, particularly departmental variations in high schools and the changes due to dividing or consolidating classes. Fixed seating in these situations necessitates "doubling up" and makeshift accommodations in some rooms, while seats are standing idle in others. Aside from the costs and delays of moving fixed seats, the inflexible arrangement usually means that no changes can be made without resetting all the seats of a room. With movable seating it is only necessary to slide a few seats from one room to another, and the complete rearrangement of a room is but a matter of moments. The shifting from one building to another is almost as simple.

The percentage of desks of each size that will be required in an entire school remains practically unchanged from year to year, but it often happens that the pupils of a given class will average unusually large or small. Interchange of movable seats among the classrooms readily provides for such variations. There is a tradition, apparently inherited from the ungraded schools, that the

large pupils should be at the rear of the room, and stationary seats are usually so set. The fact is that oversized pupils are often those who are retarded because of physical defects, low mentality, or troublesome conduct. All these may be reasons why they should be placed close to the teacher, where they are more easily supervised and teaching-pressure is more intense, or in particular locations favorable for their better audition or vision.

Flexible methods and the social spirit. Undoubtedly the strongest argument for movable seating is that it lends itself to the modern spirit and methods of teaching. The best teaching is hampered by formal rigidity in either methods or equipment. We can hardly conceive of the master teachers of whom history tells us teaching their disciples in immovable straight lines. The fire of teaching-enthusiasm is damped by geometrical rigidity. The ideal of the modern class is a social group collaborating in the acquisition of knowledge, mutually contributing to the solution of problems, or discussing in parliamentary fashion matters of common interest. The old idea of the teacher as lecturer and the class as auditors has given way before the new ideal of a group of self-directing coworkers under the leadership of the teacher. And so pupils, instead of sitting one behind the other in rigid line, should face each other in informal groupings. For the attainment of these ideals movable seating seems to be indispensable. Most especially is such equipment essential to the successful working together of pupils in flexible and changing groups.

Theory versus practice. To all these ideals we most sincerely subscribe and to the value of movable seating as a means to their realization. Nevertheless it is well to face the facts as they exist. The writer has recently

visited hundreds of the best representative schools of the country, and we do not hesitate to say that more than 95 per cent of the movable seats are set in straight lines and are never moved in any purposeful way except by the janitors, and with none too good grace by them. In the cases where they are moved with the definite intent of socializing the recitation or facilitating group activities among the pupils, perilous lighting situations are often introduced and the social aims not attained. In many schools where movable seating was introduced to break up the rigidity of monotonous straight lines the teachers have only one objection to the desks — that they cannot keep them in line! Large tables are sometimes used, about which the pupils sit faced in various directions (in violation of the principles of lighting) as a means of "socializing the class" and facilitating "group work." But there is no discoverable difference in method in any wise related to the furniture; in fact, furniture of this sort directly defeats both these ideals. No class is less socialized than one which is divided by the equipment into eight or ten separate and unrelated groups, with the backs of half the class turned to the teacher or to any pupils who may be addressing them, and with no unitary focus possible. The social group is usually the group of the whole or of a large section. I have yet to find any classroom where groups determined by the size of the table were working as such. I have been taken to an elementary class in citizenship which was seated at tables of four to exemplify the social ideals of the course, only to find each individual studying his book and reciting with no reference to his table mates, and the teacher frank to confess that the grouping had no relation to the work. In one of the largest American high schools

a department head explained at length that pupils were seated six at table because "six is an ideal study group," but there was no group of six that had any problem, project, or task in common or who were working, or apparently ever did work, as a unit. Other departments of the same school find the traditional straight-line arrangement of fixed desks better adapted to socialized and group instruction than are the large tables.

Atmosphere and liberty of movement. Some kinds of equipment are sought or defended on the ground that they impart "a homelike atmosphere" to the room and that they allow "a natural freedom of movement." These are loose expressions which mean precisely nothing when analyzed; nevertheless they often become determining factors in the selection of equipment. What home has or should have an atmosphere favorable for the intensive study of thirty or forty pupils in one room? Is not home study commonly restricted and often prohibited precisely because the atmosphere (meaning confusion, distractions, furniture, lights, etc.) is not favorable to concentration? The atmosphere of the schoolroom ought to be and almost invariably is far better for school purposes than is that of even the best homes, precisely as an office atmosphere is better for office work. Again, "a natural freedom of movement" has no more place in a crowded schoolroom than it has in a busy factory, a crowded office, a church, a theater, a street car, a line before a ticket window, or any other place where many are associated together and each must restrain his liberty of movement in behalf of the mutual interests of all. There should, indeed, be no unnatural restraint or awkward repression, but the school has no more serious duty than to train pupils to adjust themselves habitually to the conditions of work

FIG. 39. Informality at the cost of posture and vision. A room of unusual charm in an excellent school, but the striving for "atmosphere" resulted in all but about six of these children facing the light or having it on the right or so that their shadows fell on their work. Because of lighting and equipment, posture is bad in nearly every case. Note the flowers on the tables, but also the books and materials for which no other storage is provided. Compare Fig. 51, which shows a room of equal charm, atmosphere, and liberty

most favorable to all. Nor can we discover that either "atmosphere" or "free movement" is much affected by the furniture, except possibly in the kindergarten and the primary room. There are adequate reasons for the use of movable furniture, there are conditions where it is desirable and others where it is not, there are forms which are advantageous and others which are not; but we shall make headway toward better school equipment not by meaningless phrases but by careful determination of the objectives for which it is employed and then by such use of the equipment as will positively attain these objects.

True aims of movable seating. Let us, then, as a basis of further discussion, agree upon the real ideals and purposes of movable seating. First, it should be hygienic, comfortable, sanitary, attractive in design and finish, durable, and economical. These ideals apply equally to stationary types; and if movable seating fails in any of these respects, it should have difficulty in securing the preference over stationary seating which does not so fail. As between various types of movable seating, these should be the first standards for comparison and reasons for choice. And first among these stands the hygienic ideal, without which no seating is worthy of choice. Having passed these tests, the furniture should be judged as to its satisfactory mobility. It is just as objectionable that seats should move too readily as that they should not move readily enough. The furniture should be convenient for definite and purposeful movement, but not such as is unstable or requires unnecessary or useless movement. It should be favorable to individual concentration and study, without annoyance or distraction, or it has failed in a primary purpose of school equipment. It should be favorable to the socialized activity of the

class as a whole, since, next to the individual, this is the group which most commonly functions in a unitary way. It should be favorable to the functioning of large groups, consisting of a third or half or other section of the class, since these are the typical groups which work together under the leadership of the teacher. Finally, it should be favorable to the working of small groups, varying from two upward but of no fixed size or composition. These are the special study or project groups, selected by the exigencies of instruction or common learning needs and by no numerical standard of an ideal study group. Also it should be well adapted to the moving incident to cleaning the room, transferring from room to room, and converting the room for various uses etc., as mentioned in the paragraph on building and equipment economies. Obviously the equipment should involve no waste of floor space nor any factors conducive to annoyance, disorder, or difficulties of discipline, nor should it lack any conveniences favorable to the best educational conditions. It should be said parenthetically that we are discussing standard classroom seating for grades and high schools and not for kindergarten and primary classes.

A single unit for each pupil. If the foregoing is a fair statement of ideals, it would seem of first importance that the seat and desk of each pupil should be entirely separate from that of any other, both as a condition to individual concentration without interruption or annoyance and to permit of combining in any sort of grouping. Both these aims are defeated by the use of tables at which two or more pupils are seated. Furthermore, a seat and desk combined into a single unit are preferable to a separate chair and table for several reasons, which may be briefly stated. There is but one piece instead of

two to move, and because of the construction the one is usually more easily and quietly moved than either of the two. Seat and desk are always together and in proper hygienic relation to the pupil and to each other. Loose chairs cannot be kept with the tables for which they are intended without a great deal of trouble and confusion. Despite all numbering devices, neither pupils nor janitors can readily be trained to do this. It is not done. Usually there is no effort to do it. Even if this were possible, it has been found impracticable in this type of equipment to secure the range and assortment of height relations usual to good school desks, and there can be no control whatever of the spacing (plus or minus distance), which is a prime essential to good posture. The necessity of moving the chair back from the table whenever one enters or leaves his seat, rises at his place, or opens a table drawer to get at a book, requires some 50 per cent of additional floor space per pupil, is injurious to flooring of the better sort, racks the chairs and reduces their period of serviceability, causes more or less noise and distraction, and commonly involves bumping against the table behind. Unless heavy and expensive, individual tables are liable to be fragile and unsteady since they lack the stability provided by the weight of the pupil himself and the broader floor base of the combined unit. Also, it must be evident that as yet nearly all chairs available and used for this purpose are much inferior in hygienic design and proportions to most of the better school-desk seats.

Stability and panic danger. A further objection to two light and separable pieces instead of one more stable is the danger in case of panic. In fact, the objection is apparent in the regular passing of pupils to and from the

room, for unless they are careful to replace the chairs as they rise, passageways are easily cluttered, chairs are overturned, and at best the room is left in more or less disorder. Some cities in their fire and panic regulations prohibit the use of movable seating in all places of public assembly, including schools. A discrimination should be made between the seating which is really unstable and a panic hazard and that which is not.

Ideals and defects in movable desks. Much criticism has been heaped upon movable desks because of structural and mechanical inferiorities. The defects existed because this desk involved radically new problems of strain and construction, because many of them were produced by concerns which were inexperienced in the business and poorly equipped, and because too many complex devices and adjustments were attempted. The criticisms are wholesome and are forcing manufacturers to develop better and better products until the same degree of mechanical excellence, finish, and durability, and the same hygienic proportions can be had in movable as in the better-established stationary lines. Unfortunately, structural defects in particular types were regarded as objections to movable seating in general. The writer has frequently had stated to him as objections to movable seating that "the drawers stick," "the tops are unsteady," or the "legs get broken," or other matters utterly irrelevant to the mobility of the furniture, though the most common objection has been that "they get out of line," which is precisely what they are intended for. The mechanical defects can be remedied, and the same strength and durability to be found in the best stationary desks should be insisted upon, but it is to be expected that they will cost more than in desks which use the

floor as part of the construction. Furthermore, the problems of rigidity and stability should be worked out until there is no appreciable vibration or possible sagging of the desk top and no danger of overturning under any of the normal vicissitudes of schoolroom usage. Large and symmetrical floor base and low distribution of weight are essential to stability. Ease of movement demands smooth gliders which cannot wear out and will not injure the best of floors. It further requires that there be no chattering or noise when they are moved nor any tendency to "crawl" as the pupil moves and shifts about in the seat. The lateral springiness of vertical legs is the most prolific cause of these tendencies, and hence legs which have a considerable curve are in this respect preferable. If there are adjustable or moving parts they should not only be mechanically perfect at the time of delivery but should be so constructed that they will remain so despite the strains of moving and hard usage. Book drawers and overhanging tops are the most common sources of annoyance and should be required to pass most searching tests. Since movable desks are readily interchangeable, and can be supplied in assorted sizes, size adjustments are of minor importance and should not be introduced at any sacrifice of strength or rigidity. Like other school desks they must be fool-proof and boy-proof, which means that there must be no tempting nuts or screws which may work loose or be detached by budding mechanical geniuses; nothing that will get out of order by meddling and "monkeying."

Chair-desks. The chair-desk is the original and most widely used type of movable desk. It consists essentially of an ordinary chair with a desk top supported from one of the forward legs extended upward and usually

projected forward for the purpose. Having evolved from an ordinary wooden chair, the chair-desk has been slow to overcome the prevalent hygienic defects of such furniture, which is usually crudely formed with seat too deep and back badly shaped, and proportioned for adults so far as rationally proportioned at all. Hygienic design suited to the pupils who are to use the desks should be demanded. The extension of the top to the back as an arm rest is a convenient and economical method of bracing the top, but is seriously objectionable hygienically for reasons explained in Chapter V. The device is a manufacturing advantage for which the pupils pay dearly. An effective and durable method of bracing the top is the most serious of the structural problems involved in the chair-desk. Its attachment at one side of the chair, traditionally the right, limits ingress and egress to the opposite side. The overhanging top, with its tendency to make the chair top-heavy, is another difficulty, which is partly overcome by extensions of the legs and by keeping the weight of the unit as low as possible. Book storage is usually provided for in a drawer under the seat. This is an advantage in that it eliminates the box under the desk, but is a temptation to make the seat larger than it should be. The drawer adds considerably to the cost, is usually more or less unsatisfactory in operation, is in the way of passers-by when it is left open, and is not well shaped for book storage. These difficulties are inherent.

FIG. 40. A steel-frame movable chair-desk

Unless closed book storage at the seat is necessary, it is better to eliminate the drawer; but in this case the box which replaces it should be solidly inclosed front, back, and bottom, with no ledges to catch dust. The discussion of desk-top adjustments in the preceding chapter is applicable almost exclusively to the chair-desk type of furniture, since tilt and distance adjustments are now rarely found in any other type. Other types of movable desks will not be discussed separately, because they are essentially regular school desks with seat and desk united into a movable unit. (See Fig. 38, p. 217.)

Method in moving movable desks. For regular class purposes there is some one arrangement of the seats which is best for each room and which is determined by the window lighting primarily and by teaching, discipline, and class-movement considerations. This best arrangement will ordinarily be the "quadrant plan," which is described in the following chapter, particularly as this plan is flexible and can be equally well adapted to any variations in window placing or room dimensions. Whatever may be the regular arrangement it should be clearly understood by pupils, teacher, and janitors, and they should be trained so far as necessary to replace the seats in this arrangement with the aid of such floor marks or other guides as may seem best. The values of movable seating are not attained by any chance, aimless, or helter-skelter movement. Particularly if the room is well filled, as schoolrooms usually are, the mobility of the furniture will cause confusion unless the standard arrangement is very definitely planned and easily restored. If the room is overcrowded, it may be entirely impracticable to do any effective moving for the sake of grouping or other recitation purposes. The regular

arrangement will be that which is best adapted for the class working as a unit, and hence the one used the greater part of the time. When, for some definite teaching reason, any considerable portion of the class should be reciting as a group while others are studying, the former may turn their desks about to face the inner or rear wall and blackboard where teacher or reciting pupils stand. This not only distinguishes the pupils of the group, but helps to avoid the distraction of the others by not having the activity and demonstration directly before them. This shifting involves drawing the desks out of line and more or less intruding them upon the aisles; hence pupils should be trained to move the desks quietly and restore them promptly to position when the group recitation ends. It is often desirable for a small group to be gathered close around the teacher for special instruction or drill. The open space provided in the quadrant plan, with perhaps a slight shifting of the front row, makes it possible for a considerable number of desks to be arranged in a close arc or semicircle at the front of the room. When there is definite reason for a small group of any number to study or work together upon some project as a unit, one or more of the rows, preferably at the front or the back of the room, may be moved into a convenient cluster for the purpose. All these suggestions are susceptible of innumerable variations, but care should always be taken to avoid having any pupils face a light or glare. When it is desired to clear the larger part of the floor for games, dramatics, etc., desks may be shoved back against all four walls, facing inward and leaving space for pupils to enter or leave desks readily; or they may be massed as closely as practicable at the rear of the room, leaving half or more of the front part clear. There are games,

drill exercises, etc. in which it may be desired to divide the entire class into twos, threes, or fours. In such cases there should be a regular plan adopted for facing the desks together in the most effective manner. For any such shifting which is likely to occur repeatedly it is well to make a careful preliminary study of the space available and to devote some time, if necessary, to securing the best possible arrangement, and then to practice pupils until the movement is made with expedition and without confusion. There should never be any disorderly shoving or bumping about of the desks, nor any movement which introduces bad lighting conditions, nor any which does not have or which fails to attain some definite educational purpose.

Equipping for the future. The majority of teachers who are provided with movable seating do not as yet make intelligent or profitable use of the mobile feature. Many, indeed, are still prejudiced against any sort of furniture which is not screwed down to the floor and, moreover, seem to regret that the children are not also screwed down. But teachers are movable, whether or not the desks are, and an installation of good desks will ordinarily outlast many poor teachers. Equipment is purchased for the future, and during the life of an installation there will be many changes of teachers and probably more or less radical changes of method. What the demands of the future shall be, only the future can tell; nevertheless all indications are that flexibility in method will prevail. But it will be a conservative flexibility which eschews aimless looseness as it does repressive rigidity. The effective working ideal is somewhere between the inflexible traditions of reactionaries and the impracticable dreams of visionaries.

Stationary seating equipment preferable for some uses. Having considered the advantages and limitations of movable equipment, one should add that there are schools in great numbers throughout the whole country in which conditions are such that for the present at least no advantage and perhaps decided disadvantage would follow its introduction. So long as rooms are so overcrowded that no space is left in which to move seats, or teachers so overtaxed or poorly prepared as to be unable to direct the movement or to secure the educational advantages of the mobility, or systems so routinized and cumbersome that teachers cannot be trained to do these things, there may be no educational advantage in equipment of this kind. The theories and methods of instruction which demand movable equipment are by no means universally accepted even where conditions would otherwise be favorable. There are many who hold that movable equipment is well adapted for primary and for advanced grades, but that stationary equipment is preferable in the intermediate grades. The extent to which its use is advisable for classroom purposes must be determined by experience and local conditions.

For auditorium seating (except where the room is to be converted to other purposes by removal of the furniture) there can be no question that fixed theater chairs are desirable. Similarly, for lecture rooms in which large classes are to be accommodated, and where there is no probability that any change in arrangement is to be desired, pedestal tablet-arm chairs fixed to the floor afford the most compact seating and avoid much confusion and loss of time in the changing of classes. These may indeed be more favorable to effective floor-cleaning than a large number of movable pieces which must be moved and

rearranged at great cost of labor and with the inevitable slighting of it when the room is swept.

Another desirable use for stationary chairs which has not been sufficiently appreciated is in libraries, sewing rooms, laboratories, lunch rooms, and similar places where stationary tables are employed. For such purposes there are many advantages in fixed pedestal seats, which are easy to clean around, avoid the noise and disturbance incident to sliding chairs up to and away from the table, never fall over or clutter up the passageways, require considerably less space than loose chairs, are always just where they are wanted, and maintain the fixed relation to the tables which is most favorable to good posture and lighting. Such pedestal seats may be obtained with a swivel which permits them to turn just far enough for easy and orderly ingress and egress, and with adjustments which permit of the most suitable height relations to the tables with which they are used, and in this form provide what seems to be an ideal equipment for use with stationary tables.

Summary. In conclusion, the special advantages of movable seating may be briefly summarized as follows: (1) it avoids injury to floors, (2) it facilitates thorough cleaning, (3) it permits proper adjustment to light, (4) pupils may be distributed about the room as desired, (5) interchange of seats is easier than adjustment, (6) seats may be interchanged between rooms or schools to provide for varying size of classes or for administrative shifts among classrooms and to avoid waste of unused equipment, (7) it makes rooms convertible for various purposes and thus may make large economies possible in building, and (8) it is favorable for flexible methods of teaching, group instruction, and socialized recitations. Limiting

factors which may become objections are as follows: (1) instructional values are most commonly not attained, (2) superior teaching is required to insure the possible advantages, (3) lighting conditions may be made worse instead of better, (4) mechanical and structural defects must be overcome, (5) unstable equipment introduces elements of noise and confusion, (6) some forms revert to many objectionable aspects of double or multiple seating, (7) some forms introduce postural evils by sacrificing proper relation of seat to desk, (8) some consume unnecessary floor space, (9) fire and panic hazard. None of these objections are inherent in movable seating, but are incident to misuse or improper forms of it. Stationary seating is better for some classrooms, for auditoriums, for most large lecture rooms, and for use with fixed tables. Further suggestions as to the effective use of movable seating are given in the following chapter on seat arrangement.

CHAPTER XVIII

SEATING ARRANGEMENTS IN THE CLASSROOM

The objectives. The purposes which are to be accomplished in arranging the seats in a classroom are (1) best direction of light on every desk; (2) unitary focus of the class, so that for ordinary recitation purposes all will face toward a common point; (3) pupils facing toward well-lighted blackboards and away from windows; (4) favorable arrangement for supervision by teacher; (5) economy of floor space; (6) aisles convenient for travel to and from door; (7) pupils not to be in such proximity to each other as to obstruct the view of some, (8) nor so placed as to be tempted to mischief or too much communication, (9) adequate and well-shaped space for class activities at the front of the room.

Classrooms are now ordinarily standardized at 22 by 28 feet or thereabouts. Regulations commonly require that aisles between rows of desks must be 18 inches, those next outer walls not less than 24 inches, and those next inner walls not less than 30 inches wide. As explained in Chapter XV the spacing of the seat with reference to the desk should be measured from the lumbar back support to the near edge of the desk, being about $10\frac{1}{2}$ inches in the lower grades and 12 inches in the higher. If support at the lumbar level is not provided, this measure should be taken from approximately where the lumbar concavity of the average pupil would be if he sat erect and as far back as the form of the seat and back permit him to sit comfortably.

The plans shown in this chapter are drawn to scale for a standard classroom, 22 by 28 feet, and for the large-size desks (No. 1 or Size A adjustables), which usually require a total space 24 inches wide and 33 inches deep. Smaller-sized desks, or those whose spacing is different from this, would be rearranged accordingly.

Fig. 41 shows the traditional straight-line arrangement properly spaced for aisles and No. 1 desks. Thirty-five

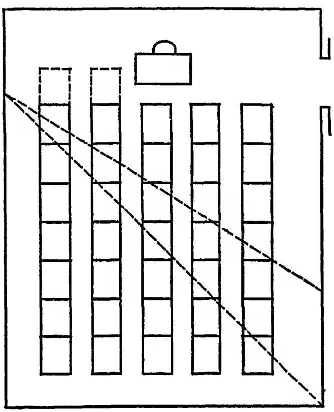


FIG. 41

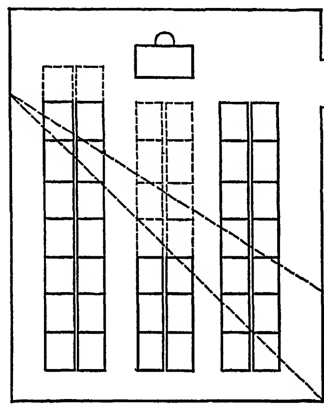


FIG. 42

sittings are provided, with two additional by overcrowding in emergency. Pupils sitting behind the lower diagonal, drawn from the front edge of the window area, have a serious glare in their eyes, and those behind the other diagonal a slight glare. Pupils sit directly in front of each other, obscuring the vision of those behind.

Fig. 42 shows seats arranged in double rows, practically a reversion to the obsolete double desks and usually resorted to only as a means of overcrowding rooms. Maximum sittings increased to forty-four. Sometimes used as a means of securing open space for class activities,

ten desks being removed, as indicated by dotted lines. Interior aisles are fewer but are required to do double duty.

Fig. 43 is a plan advocated to avoid pupils' sitting close behind each other. Their diagonal proximity is probably no less objectionable; access to seats is from the right side only; aisles are convenient in direction but

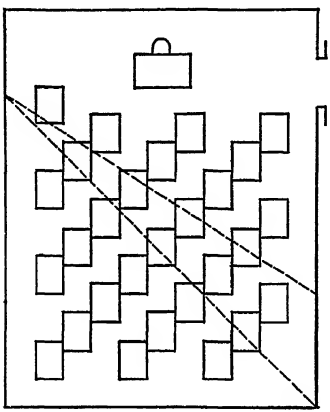


FIG. 43

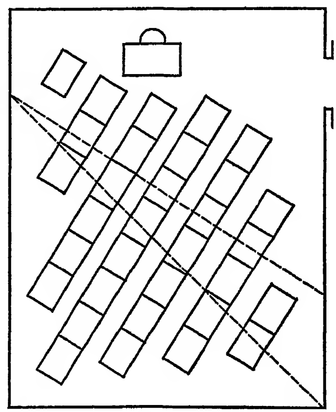


FIG. 44

saw-toothed in form, making frequent bumping against desks probable; light is no better than in the traditional plan; the plan is extravagant of floor space, providing twenty-eight sittings; it is not adapted for use of combination desks.

Fig. 44 is a suggestion available for combination or any other type of desks: good lighting angle at all desks; pupils face in best direction; aisles straight with shortest travel lines; moderate floor economy, thirty-two sittings; unobjectionable except for general prejudice against diagonal lines.

Fig. 45 represents any formal arrangement of large tables seating several pupils facing in two (or more) directions. For those facing forward, light is as in the straight-line plan; for all others it is distinctly bad; arbitrary fixed grouping antagonizes all flexible-group and large-group socialization, individual study, or the work of the whole class as a unit; chair movement

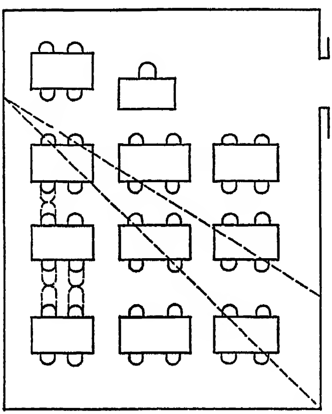


FIG. 45

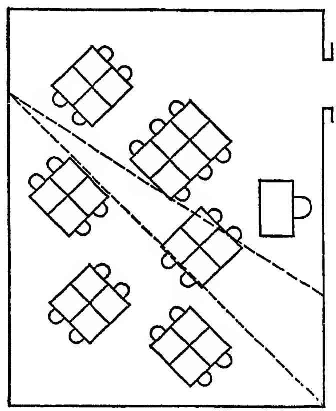


FIG. 46

results in confusion and waste of floor space; suitable adjustments or assortments of sizes are impracticable.

Fig. 46 is typical of many variations of informal "home-like" arrangements. Large tables or small ones are combined variously; pupils facing in diverse directions have bad light in the majority of cases; there is no assurance of hygienic relations in height or in the relative position of seats and tables; the plan is decidedly extravagant of floor space. (See Fig. 39, p. 233.)

Fig. 47 is one of many variations of the "hollow square" plan used in primary grades to provide open

space in the center and an informal "socialized" arrangement. Light is bad for every pupil in the plan shown and in most variations of it. Continuous tables or combinations of them prevent the assortment of heights necessary to good posture in grades where much writing is done. Facing of pupils together across narrow tables is conducive to the spread of colds and epidemics and is

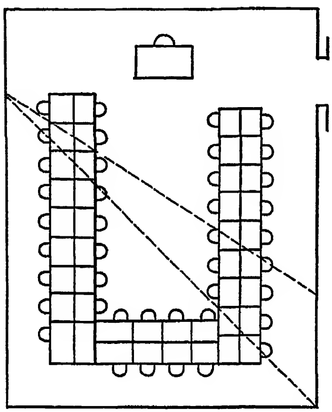


FIG. 47

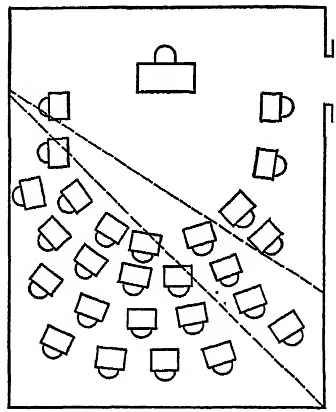


FIG. 48

otherwise objectionable. Without this facing of pupils together, the plan is extravagant of floor space.

Fig. 48 is an informal semicircular arrangement: unitary focus, but disorderly, wasteful of space, and pupils in right half of room face the light. Formal semicircles (or circles) are too extravagant of space to be considered in rooms of this size, as are also rows radiating fanwise from a center.

Fig. 49 shows tablet-arm chairs in most compact arrangement possible — sixty-four sittings crowded into a standard classroom. Suited only for lecture purposes.

Fig. 50, on page 252, is a plan developed by the author to meet the objectives stated at the beginning of this chapter. It will be found that each desk has the best light possible at that position in the room, which is impossible if all pupils face in any one direction. All face toward the best-lighted blackboards and a large, well-shaped space for class activities. The appearance of a class so arranged is particularly attractive. Aisles are arranged in two directions conveniently for door at front or rear. View of or by the teacher is not obscured by pupils' sitting close in front of each other. The cross passages are particularly convenient for supervision of seat work. The plan is economical of floor space; forty-five seats are shown in a room 24 by 32 feet, and thirty-nine are accommodated in a standard 22-by-28-feet room, indicated by inner dotted line. Several others can be added in emergency by using the center aisle and part of the open space.

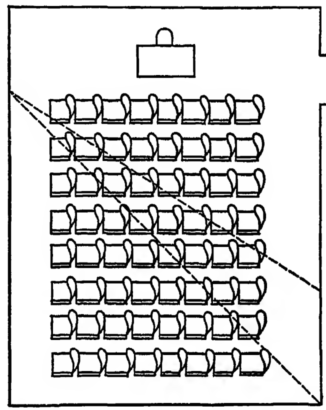


FIG. 49

This plan is essentially flexible and subject to indefinite variations without sacrificing its advantages so long as the approximate relation of seats to the light is preserved. In some rooms the rear row is omitted and this space used for a class reading table and bookshelves. The seats at the left-front corner are variously arranged, those turned to face the inner wall being ideally situated for left-handed pupils, who thus have their light over the

right shoulder. This is the only definite provision for left-handed children which the writer is aware of, yet they suffer as much from left-side light as others would from right-side light.

The arrangement as shown in the plan is somewhat overcrowded though entirely practicable. By removing one desk from each of four or five rows and distributing the space thus gained between the desks of the rows, any objection to having pupils sit too close to each other is avoided. The teacher's desk may be placed in the left-front or left-rear corner by omitting some of the desks shown, or it may be placed close to the front of any of the front-row desks, according to preference.

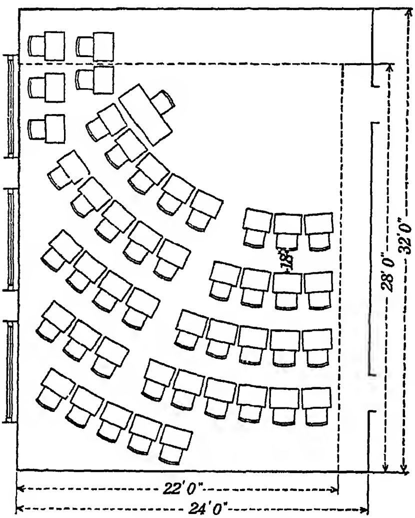


FIG. 50. Author's "quadrant" plan of seating

In general, the design is to arrange the desks in four arcs and part of a fifth, the center being near the right-front corner and cross passages being eighteen inches wide. For most desks the placing is better if the arcs on the window side straighten out into tangents. A simplification, quite as effective, is accomplished by having all the rows in straight lines — those on the right of the center aisle facing forward and those on the left facing

FIG. 51. An adaption of the "quadrant" plan at the Elementary School of The University of Chicago. Note the excellent light on each desk and the light over the right shoulder of the left-handed boy next the window in the second row

as shown. The plan is adapted for any type of individual desks, movable or stationary, except combination desks, which must be set in straight lines. Chairs separable from the desks have the usual objection that they clutter the cross passages.

The flexibility of the plan makes it particularly effective in irregularly shaped rooms and those with window lighting irregularly distributed. In a large square room with light along two sides and part of a third, the arcs were very advantageously made practically semicircles with the unlighted corner of the room as a center.

Where movable desks are used, particularly in a rather complex plan such as that in Fig. 50, it is well to work out the placing with care and experiment and then mark the position of each row or each desk on the floor as a guide for pupils and janitors in preserving the correct arrangement. This may be done by paint marks or brass-headed tacks. Temporary crayon marks will serve to keep the plan effective until it is understood and appreciated, after which janitors and pupils should have no trouble in replacing the desks as planned. Where stationary furniture is used, it may be wise to experiment with the placing for a day or two before fastening it down. It will be found that the ideal placing of the desks with reference to the light is somewhat affected by the position of the sun at various times of the school day and by neighboring walls, trees, or other objects which either reflect or obscure the brightest light. These conditions, however, will not change the general character of the plan. Such factors as a cloakroom door or cabinets at front or rear of the room must also be taken into consideration.

CHAPTER XIX

CHOICE OF SEATING-EQUIPMENT

The type of seating best for a given grade or room should be determined on the basis of the dominant type of work for which it is intended. There is no one best type.

Kindergarten. For kindergarten use there is practically unanimous agreement that there should be light chairs and tables. Some teachers prefer tables about 30 by 72 inches; others prefer small tables about 20 by 36 or 48 inches which the children can move about readily and arrange in different formations. Space may be economized by the use of folding tables, which the children put out of the way when not in use. Tables are used mainly for manipulating objects, for cutting and pasting paper, and the like, and no problem of correct writing-height is involved. In order that these things which the children are learning to know and manipulate, and the movements which they are learning to make with the guidance of their eyes, should be learned in a reasonable perspective without too much distortion, the tables should be low enough to enable pupils to see the entire operation and not merely the edge of it. Twenty inches is sufficiently high for such a table, and there is little advantage in any gradation or assortment of sizes, the convenience of having them all the same height probably outweighing the desirability of suiting the tables to varying sizes of children. The height of the seats, however, is a very

FIG. 52. Perfectly seated in a chair two inches lower than her measured seat-height

different and a very important matter. Children of this age are more susceptible to injury from improper seating and to the formation of habits of improper sitting than at any later period. Only the saving grace of incessant

movement and restlessness prevents serious postural injury in the kindergarten, for there, as elsewhere in the schools, seats are almost invariably too high. Measurement and observation show that the usual 12-inch and 14-inch chairs for kindergartens are inexcusably high. Children of this age are mostly very plump and chubby, with rounded, fleshy limbs, and hence require seats an inch or more lower than the .25 ratio would indicate. Kindergarten chairs should range from 9 to 11 inches in height and be but 8 or 9 inches in depth. The back support should be at least 6 inches from the seat, well rounded at the edges, and with sufficient space between the uprights to permit the child to sit well back against the support.

Primary grades. The first grade, particularly the lower first, is conducted as a transition stage between the kindergarten or pre-school life of the child and the formal work of the grades. It may be equipped accordingly either with seating favorable to some writing and book work or with chairs and tables suited to kindergarten projects, or with a combination of the two. Since play constitutes a major part of the curriculum, seating should be movable and light enough to be readily moved by the children. Within these limits no fixed rules can well be made, and the preferences of individual teachers or supervisors should be considered. A complete double equipment is not necessary, although it is desirable that every pupil should have his individual desk if much writing or reading is required. One or two tables with chairs enough for half the children at a time can be used to supplement an equipment of regular seats and desks.

In the second grade, or the third at latest, the work done at the seats becomes dominantly reading and

writing, and it is important that the equipment be favorable to individual concentration and study. We are not advocating an excessively formal or sedentary schedule in the primary grades, but, even though it be for very short periods at a time, when a child is endeavoring to read or write, he should be able to do so without annoyance or distraction. Educational economy and efficient habits of study demand that the child learn very early to work while he works and to play while he plays. He gets off to a bad start in his educational career if during the primary years, when his fundamental thought habits are forming, he is constantly subjected to bumping of elbows and chairs, shaking of tables, and scraping of furniture on the floor. Concentration is particularly difficult at this time, and conditions should be made as favorable for it as possible. Teaching-methods as well as seating-equipment should be devised with this in view.

In these years infantile frailties and predispositions develop into visual and postural defects, since it is then that sustained sedentary and eye-straining work is first required. It is therefore peculiarly important that the greatest care be given to physical inspection and oversight and to the provision of the most perfect hygienic seating possible. In comparison with the lifelong welfare of the child, which may be in the balance, no question of the cost of competent supervision, of the price of seating which is hygienically right, or of the price of its faithful adjustment should be considered. Whatever science and thoughtful care can do to protect the child from undue eyestrain and to insure the development of hygienic posture habits is more important to the individual's worth to himself and to society and to the ultimate financial saving for the school system than are other

considerations of teaching-method or budgetary balancing. The proverbial ounce of prevention here is better than pounds of cure in higher grades. Eye defects developed here may be incurable and only alleviated by the wearing of glasses for a lifetime. Neglect may quickly set up postural habits, to say nothing of the physical ills entailed, which years of later watchfulness cannot correct.

A transition period. In curriculum and schedule these later primary grades are merely farther along in the transition between the incessantly changing, dominantly physical, and sensory play activities of infancy and the more sustained, concentrated, purposeful mental activities of maturity. Free play is still sufficiently closely interwoven with other classroom activities to make movable seating a very valuable feature. A supplementary equipment of light kindergarten chairs or small folding chairs will admit of a larger range of effective teaching processes. A folding table from four to six feet long which may be used variously for class projects, construction work, reference books, or sundry display purposes, or which may be put entirely out of the way when not in use, is an important adjunct.

Intermediate grades. In successively higher grades the work of the classroom is more confined to study and to distinctly sedentary class activities, physical activity being segregated more to the physical-training and recess periods. Sitting is more continuous, reading and writing more sustained, and for this reason posture and lighting problems take on an added significance, even though the susceptibility of the pupils may be less than in the primary grades. Movable seating in these grades has its value primarily because of its adaptability to flexible

grouping and self-directed class organization. The use made of it will depend on the degree in which the teacher has become a guide, a director, and an inspirer rather than a formal instructor. Correct adjustment for writing-position is peculiarly important in these grades, and, of course, seat-height, seat-depth, and back form are always important for the physical welfare of the child.

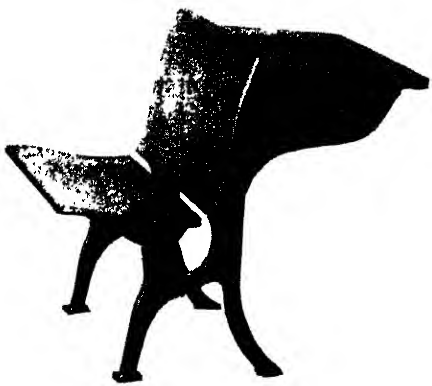


FIG. 53. A modern combination desk of steel construction

Combination desks. There are several standard types of seating in general use for regular classroom purposes, each having its distinct claims to superiority. By far the most commonly used is the familiar "combination desk." Quantity production has enabled manufacturers to develop in this desk a piece of furniture which is structurally as near ideal as human ingenuity and skill can make it. The better makes of combination desk leave practically nothing to be desired in rigidity, strength, durability, mechanical perfection, graceful design, finish, or sanitary construction. Considering the elaborate manufacturing and distributing equipment and organization necessary to supply these desks and the practically perfect materials and workmanship which go into them, prices are surprisingly low. Considering their indefinite durability the cost is trivial indeed. Some of the earliest cast-iron

combination desks made are still in service, and it is doubtful if the best modern steel-frame desks will ever wear out. For all that anyone knows they may last for centuries of continuous use if future educational policies continue to tolerate them. Any sacrifice of superiority in finish, appearance, or design for the sake of a difference of a few cents in the initial cost of such equipment is a short-sighted, niggardly policy with little semblance of economy.

These combination desks are regularly supported on standards at each end and have folding seats the full length of the desks. This provides a maximum of stability and solidity. The better ones have seat hinges that are silent, smooth in action, and practically as indestructible as the steel frame itself. The seats and backs necessarily have a straight-line contour laterally and usually have a comfortable and attractive reverse curve in the vertical profile. With seats lifted and contact made with the floor at four points, the facility with which the floor can be cleaned depends on the shape of the standards and on the close-fitting and sanitary construction of the feet.

Single-pedestal combination. The single-pedestal combination type makes contact with the floor only in one large round or oval foot, and is therefore easy to clean around and popular with janitors. The central support also makes practicable a narrower and better-shaped seat and back than in the ordinary combination type. Seats are immovable, and backs are attached to the seat instead of being a part of the desk behind. The narrow seats are more convenient for ingress and egress without lifting, but the large supporting pedestal may be in the way of the feet of the sitter. This latter fact may encourage a habit

of sitting with both feet on one side of the pedestal, which would undoubtedly have a tendency to cause scoliosis, though we have no data showing that this actually occurs. The great leverage on this relatively narrow floor support necessitates a particularly strong floor attachment and often results in its working loose if floors are soft, if the screws are too small or too few, or if the foot of the pedestal is not well shaped. The supporting pedestal is indestructibly strong and rigid, but the attachments of seat and desk top are not necessarily so.

FIG. 54. A combination desk of the single-pedestal type, adjustable and equipped with study top instead of usual book box

Either type of combination desk may be had in adjustable form, though often at some sacrifice of rigidity and durability. They are always stationary and are not adapted to any except straight-line arrangement. The entire row, from front to rear, constitutes a unit of installation, and the position or spacing of one desk usually cannot be changed without moving the rest of the line.

The stationary desk and chair. Completely individualized seating is provided in the widely used stationary desk and chair. The desk has standards (usually adjustable) at both ends, making it very rigid and strong; and the chair may have similar supports or an adjustable pedestal which, being centrally placed, has unlimited strength.

The two pieces constitute a complete unit and may be set in any desired arrangement, or the position of one relative to the other may be changed without affecting other units. An important advantage of this over any combination seating is the complete freedom from annoyance of jarring by the pupil in the seat in front or at the desk behind. This independent construction also admits of the most perfect design of seat and back of which the manufacturer is capable. The narrow seat allows easy ingress and egress, and there is no central pedestal under the desk to interfere with knees or feet. This type of desk and seat has been brought to a high stage of development and is probably capable of any possible refinements or improvements. If it is equally well constructed, it is superior to any combination desk in several respects and has no disadvantages except the increased number of contact points with the floor and probable higher cost.

FIG. 55. A steel-frame adjustable box desk with lifting lid and adjustable-pedestal swivel chair

Open box or lifting lid. Any of the desks described above may be had in either open-front or lifting-lid style of book box. The former are difficult of access and inspection, books and materials cannot well be kept in order in them and are injured by the practice of shoving them in unseen; pupils must twist themselves down

most awkwardly in the seat or aisle to look into the box to find what they want; papers and trash of all kinds are crowded back into the unexplored recesses and sometimes remain there for months or longer. The lifting-lid boxes are easily kept clean and in order, are easy of access, and can readily be inspected by the teacher. The objections to them are more theoretical than real and can be avoided. It is objected that the pupil's work spread out on the top must be removed before the top can be raised, that pupils use the lifted tops as screens for mischief, that confusion and sometimes slight injury to hands is caused by the falling of the tops, that the tops are broken off by the breaking or pulling out of the hinges, and that hinges rising above the surface interfere with the writing-space. The last two objections are entirely obviated, and the falling tops almost entirely, by the improved interior hinges, which are attached to the wood in two directions, anchored to the ends of the box and provided with friction controls.

Book storage and study desk. It has already been indicated that for a large proportion of pupils the depth of the book box is a limiting factor in correct adjustment of desk-height to the proper level for writing. For this reason the book box should be as shallow as the absolute necessity of book-storage requirements permits. The better schools are more and more being equipped with lockers, in which pupils keep most of their individual property. This is particularly true and necessary in schools having the platoon or departmental organization, in which classes move from room to room, and a given pupil occupies one desk only during one or two recitation periods a day. In some other schools a large proportion of the books and materials used are kept in cabinets by

the teacher and distributed only as used. Where such conditions permit it, a very shallow box should be used, or, better yet, a "study desk" which has no book box or shelf under the desk top. This "study top" is particularly attractive and comfortable for study halls and for all classrooms where book storage at the pupil's seat is not required. It is a relatively new type and is deserving of much wider use than it has yet had. (See Fig. 54.)

Instructional assembly rooms. Assembly rooms are being used more and more for instructional purposes. All variations of the platoon organization provide for regular periods of auditorium instruction, usually with two or more classes combined. In the newer school construction the large auditoriums, which accommodate the entire school or large sections of it for but a few minutes a week, are frequently replaced by smaller ones which seat three or four classroom groups at a time and which are kept in use almost continuously on a regular schedule. In these rooms there is no longer any excuse for requiring small children to sit in seats built for adults. For primary children auditorium seats 12 inches or less in height should be provided, and they should be proportioned suitably to their height. For intermediate grades 12-inch and 14-inch seats are appropriate, and 14-inch and 16-inch seats for high-school grades. Only recently have opera seats properly designed in these small sizes been available, and even now many school boards are reluctant to use them, on the ground that the assembly rooms are also to be used by patrons and by the general public. This argument is not applicable to the small instructional assembly rooms intended only for lower grades, but even in those which are occasionally to be used by adults the frequent and regular use by children should

be the basis of equipment rather than the uncertain and irregular use by adults. Furthermore, most adults are as comfortably seated in a 14-inch theater chair as in one of the standard 16-inch height, and many of them far more so. Besides, most of the public exercises which are held in elementary-school auditoriums are attended as largely by children as by adults. School auditoriums, like the classrooms, should be equipped with reference to the children who are to use them. Parents may as well suffer some discomforts occasionally, as the children regularly. Parents are not injured by the discomforts of low seats, but children are injured by seats too high.

Drop tablet-arm theater chairs. A valuable modification of the theater-chair seating for an assembly room used for instructional purposes is a folding tablet-arm device. These arms drop down under the seat and do not obstruct the passageway between rows when they are not in use, they may be raised quietly by the sitter without otherwise disturbing himself or his neighbors, and when raised they afford a convenient, rigid writing-surface. No tablet arm is hygienically suited to long-continued writing or study, but equipment of this sort is very satisfactory for taking notes on assembly lectures, illustrated lessons, etc. Since these rooms are frequently used for tests, group examinations, and the like, in which it is desirable that pupils do not sit too close together, they are sometimes equipped with folding tablet arms on alternate seats. Since the chair frames designed for this purpose are not materially different from those not so designed, it may be well to install this type of chair throughout all such assembly rooms and attach the arms later in whatever numbers may be desired. Since the arms do obstruct the passageway when raised, children should be thoroughly trained

to lower them promptly when so instructed and when leaving their seats, especially in case of fire or panic alarms. If conditions permit, it is well also to set the rows of this type of chair farther apart than if arms are not provided; and in no case should a chair of this sort be used if there is any possibility of the drop arm's being caught or stuck in the elevated position. If properly made and managed, this type of equipment constitutes the most compact seating possible with provision for writing, and therefore it is peculiarly suited for illustrated lectures and other large group exercises.

Tablet-arm chairs. Tablet-arm chair seating is, in general, the most compact and convenient type for the lecture room, where the attention of students is directed mostly upward toward the lecturer or the projection screen or the stage, and the writing-surface is used for occasional note-taking. It is decidedly objectionable for regular classroom or study-hall use because of the continued visual strain, stoop, and spinal torsion involved in reading and writing on the low surface at one side. If the arm is higher than the elbow of the sitter, there is an inevitable tendency to form the habit of resting on that elbow — a habit which will induce lateral curvature if anything in the construction of a school seat can. It is therefore of primary importance that the arm support under the elbow be kept as low as practicable. A writing-surface as low as this, particularly as the close proximity of other students is likely to darken it with their shadows, affords too great a visual distance for most persons engaged in ordinary reading and writing and hence necessitates stooping over when the tablet arm is used. Recognition of this latter difficulty and oversight of the former has resulted in nearly all tablet arms being decidedly too high.

The solution is not a choice between these two evils, but the elimination of both by the simple device of tilting the tablet arm so that the elbow support is low and the writing-surface is not only raised but is brought into a far better angle with the light and with the line of vision.

Movable and stationary tablet-arm chairs. Tablet-arm chairs are offered in both movable and stationary types. Where the former are desired for any of the reasons discussed in Chapter XVII care should be taken to select those which are strong, stable, and properly proportioned. Since this is a type of school seating which can be produced in any chair factory without special equipment or knowledge of the requirements of school hygiene, the warning *caveat emptor* ("Let the buyer beware") applies with peculiar force. Enough has been said regarding what should be required in seats, backs, and arms to indicate what should not be acceptable in tablet-arm-chair equipment.

FIG. 56. A movable tablet-arm chair of tubular-steel construction

The stationary tablet-arm chairs are usually made with central steel pedestals and are therefore the last word in strength and rigidity. In most typical lecture rooms, unless it be desired to clear the floor occasionally for social gatherings, physical exercises, and the like, there is little opportunity or probability of grouping or otherwise changing the seat arrangement. The best arrangement for one lecture is probably the best for all.

Classes change in these rooms at the end of each period, and no little confusion results from the knocking about and overturning of the more top-heavy and unstable types of chairs. Passageways in either direction are soon cluttered by misplaced chairs, and the orderly seating and passage of classes is difficult if not impossible. For these reasons stationary tablet-arm chairs have a decided advantage for rooms used exclusively for lectures. If the pedestal is made to fit close to the floor in dirt-proof and waterproof fashion, it is easy to clean around it, and floors may be cleaned more quickly though not more thoroughly than with loose chairs. If tablet-arm chairs which are not stationary are used, there is a decided advantage in having those with low backs and a low center of gravity which slide easily without marring the floors (Figs. 37 and 56).

Swivel seats. A few types of school seats are now constructed with a swivel. If this feature is durable, silent, and otherwise mechanically good it has many advantages. It permits an orderly and easy ingress and egress without sliding of the knees past the standards. For this reason spacing may be as close as the best posture requires without allowance for getting in and out. Some free space is required behind the seat to allow for the swiveling, but this is found to be no more than is saved in the spacing because of it. This feature permits the pupil to turn so as to face teacher, blackboard, or class or to secure better light on his work, without having to twist his body or sacrifice the symmetrical back support. The swivel should be limited to sixty or seventy degrees each side of the central line so that pupils will not be tempted unduly to turn round for neighborly gossip, and so that chairs will remain in usable positions at all times.

High-school seating. The choice of seating for high schools still varies decidedly according to local, departmental, and individual preferences. The discussions of the preceding paragraphs are applicable here. Combination desks are much the most numerous in the older schools, whether by deliberate choice or by tradition and inertia. In the new schools tablet-arm chairs and other types of movable desks are being used increasingly. The influence of the experimental procedure of certain teachers' colleges is quite noticeable in particular geographical areas, and of others in other areas. The tendency is quite apparent for observers to assume that incidental conditions of equipment are somehow inseparable from the superior teaching genius or method for which our great demonstration schools are justly famed. The fact is that these notably superior demonstration teachers are very often quite dissatisfied with the equipment they have and equally uncertain as to what they want. There is very little agreement among the departmental specialists of different demonstration schools as to the seating equipment best adapted to their departmental needs.

For example, in one school the English room is provided with reading tables, common chairs, tablet-arm chairs, numerous shelves, stands, and tables for reference books, and with a stage for dramatizations. But in this room there are overhead lighting, abundance of space, small classes, and a teaching corps which is equaled in few public schools. Instruction in this room is of the individual and directed-study type and seldom resembles an ordinary class recitation. Other excellent teachers of English prefer a compact lecture-room equipment for class purposes and require the informal and individual work to be done independently in the library.

Certain nationally famous teachers of high-school mathematics insist upon ordinary combination desks because of the large working surface, the rigidity, and the storage shelf for books and materials, all of which are essential to the extensive use of drawing instruments required by them. Some teachers of geography and history require map drawing and the use of atlases to an extent for which no standard desk top is adequate and for which each pupil must have a table or desk space of twenty-four by thirty-six inches. Bookkeeping and accountancy classes, using numerous blanks and forms, usually have the standard "commercial desks" with extra large tops and elevated shelves for pens and ink and for extra books. These seem to be generally satisfactory and would probably prove so for the mathematics, history, and geography classes requiring large working surface. The elevated shelves have the additional advantage that they can be used to hold atlases and similar materials in upright position for reference.

Drawing. Mechanical drawing requires a level working surface so that instruments will not roll off and so that the student can look vertically down upon it at whatever point he may be working. This makes it necessary for the student to stand at his work, and a high stool (which cannot be justified from a hygienic point of view) is used merely for rest when the work permits. For drawing which can be done on a sloped surface such as an easel a thoroughly hygienic chair and back are practicable and particularly desirable. If the equipment requires that both types of drawing be done on desks of the same standing-height, then the stools should by all means be replaced by chairs of the necessary height but provided with suitable backs and foot rests, the latter preferably

adjustable. Better yet are drawing-tables adjustable as to height and slope. Drawers or drawing-board racks should not be permitted to interfere with the knees of pupils or prevent them from sitting sufficiently close to their work to secure proper postural and visual conditions.

Science classes. Science classes, including domestic science, usually require both lecture and laboratory work. Neither type can be effectively conducted in a room equipped for the other. Combination equipment has advantages for some plans of class organization and methods, but it usually violates height requirements for either the standing work or the sitting work. Economy of equipment and efficiency of schedule, as well as postural and visual hygiene and the avoidance of odors during the nonlaboratory periods, have usually resulted in lecture and study rooms being entirely distinct from the laboratories. For lecture rooms tablet-arm equipment is most popular. For much of the laboratory work no seating is desirable unless possibly stools for the occasional relief of the feet. Inasmuch as pupils are working over the tables and are constantly moving, sitting-posture is hardly a problem. Biological work, however, requiring much continuous use of the microscope, and other occupations involving a minimum of movement and a maximum of concentration in a sedentary position, are particularly trying as to both postural and visual conditions. So far as students are concerned this work is best done on low tables, with well-formed chairs adjustable in height to suit individual needs. But it is necessary for the instructor to pass from student to student in order to look through the microscopes or to examine the dissections. For him the table-height appropriate for the student's sitting-position involves an intolerable strain of bending.

It seems necessary that high tables, from thirty-two to thirty-six inches, be used, and that the students' seats be elevated to correspond. High chairs with adjustable foot rests have been proposed, but, so far as known to the writer, are not available in satisfactory designs. It would seem that the best solution is to use pedestal swivel chairs of comfortable and hygienic construction, adjustable as to height, and to mount these on individual platforms six or eight inches high, large enough to provide adequate foot rest in front of the seat but narrow enough to permit the instructor to stand close to the side of the student while supervising his work. It may be said that in many German schools pupils' seats and desks are regularly mounted on such individual platforms for the express purpose of facilitating oversight of their desk work by instructors.

Sewing classes. Observation indicates that posture and eyestrain are worst in sewing classes. This is particularly unfortunate, both because postural defects are most frequent and most serious among women and because this particular work is more nearly identical with later occupational conditions than is any other school work. Habits formed in these classes are more likely to be carried over into life. The most usual equipment appears to be any chance combination of cheap tables and chairs. When superiority of furniture has been sought, it seems to have run to better finish or greater solidity, or to a multiplicity of doubtful facilities in the way of drawers and cabinets, rather than to any intelligent consideration of hygiene. Almost universally the writer has observed a majority of the girls in these classes sitting on seats too high for their feet to rest on the floor, and many of them unable to get their knees under the tables on which they

were working. Relief is sought by sitting on the feet and by every variety of stoop and twisting. Chair backs in these classes are almost universally too straight and too high and are commonly of the most uncomfortable construction, and seats are too deep for the use of such back support as is provided. The first requisite should be chairs sufficiently low and short in the seat and with low backs providing well-formed support for the small of the back. The sewing-chairs which our mothers and grandmothers through long experience learned to love were of this general type. These should be well adapted to relaxation in hygienic posture, so that the backs will be used whenever forward leaning is not necessary for the work. It is particularly important that chairs should be so placed that (for right-handed girls) the light will come from the left and be most effective on the point of the needle. Pupils should not be permitted to face the light promiscuously or to work in their own shadows, and yet this is what occurs in the majority of sewing classes. Low tables should be provided with no drawers, racks, cupboards, or structural obstructions in the way of the knees or limbs. Long tables are most common. An excellent table, for two pupils, has been devised which is about sixty inches long, with drawers and a rack for workboxes under the middle, and with legs near the middle and at the forward corners only, so that there is no interference with the pupils' knees either in sitting or in moving in or out. Tables should be twenty-six or twenty-eight inches high. A high cutting-table may be provided for the class, but it should not be used for sewing. Ordinarily it is best that tables be stationary, in which case the adjustable pedestal swivel chairs permanently placed in correct relation to the table should be used. The swivel feature

permits easy ingress and egress as well as free adjustment to the work by turning. Additional chairs will be required for use at sewing-machines and for occasional work away from the tables.

Typewriting classes. For typewriting classes, other than those in advanced office practice, the choice of the majority of commercial schools and departments decidedly approves a very simple, compact, and rigid typewriter stand rather than the more elaborate office typewriter desks. Some of these provide a typewriter bed adjustable as to height, but the writer has been unable to find among instructors any definite consensus of opinion as to what constitutes the correct height of the keyboard relative to seat-height or elbow-height. Without clearer knowledge than is now available, it is probable that the usual standard height of twenty-six inches is satisfactory for nearly all pupils. There should be no drawer or other obstruction under the machine to interfere with the operator's legs, but there may be an extension slide and drawers for stationery at the right. Practice varies greatly as to what the student is expected to keep at the desk; but since each machine is used by several students, usually no storage of any sort is required or permitted at the desk. Elaborate office chairs for typewriting, with adjustable backs and other desirable features, are impracticable and probably unnecessary for these classes, which remain but one period a day. Since the stands are usually attached to the floor to avoid the danger of breaking the machines, the adjustable pedestal swivel chair is doubtless more favorable to comfort, to convenience, and to orderly, compact equipment than are loose chairs. In any case hygienic forms of seat and back are important and contribute both to immediate

efficiency and to the formation of desirable habits. Low backs are particularly necessary to permit the chair to be set close to the stand and afford back support while at work without interfering with arm movement.

Library equipment. For library purposes the hygiene of reading should certainly have greater consideration than that of writing. Suitable lighting, and seating favorable to erect posture while reading, should have first consideration. Principles of visual conservation apply with peculiar force to rooms devoted almost exclusively to reading. Since writing is a minor occupation, library seats may be arranged for the light to come either from right or left, but not from both sides. They should never permit the light to come directly in front of the reader nor should there be any glare in his face. Tables may well be considerably higher than school desks, but vision and posture are very bad if the book lies upon the table when read. An excellent form of table slopes at about thirty degrees in both directions from a high center, at which a level top provides a resting place for books and materials. This slope is favorable for such writing as is necessary and holds the book at a fair reading angle, though a greater slope would be better for reading if a practical means were provided to prevent the books from sliding. Hygienic seats which are favorable to erect and comfortable sitting and which positively discourage slouching and slumping are nowhere more important. Since the tendency to bad posture in reading is affected primarily by the spacing of the seat to the table, it is particularly desirable that this spacing be controlled. If tables are stationary, which should be the case unless the library is to be used for other purposes requiring the removal of the furniture, the seats may well be stationary also, and

the pedestal swivel seats, which have been mentioned for use with all fixed tables, are desirable (Fig. 57). This equipment would go far toward remedying not only the atrocious postural conditions which characterize library work and so easily pass over into permanent habits,

FIG. 57. Stationary pedestal adjustable swivel chairs used with stationary table

and the visual strain which contributes to irreparable injury, but also the unnecessary noise of incessantly moving and bumping chairs and the necessity of continually straightening and rearranging misplaced chairs. If the chairs are movable, they should be such as move silently without injury to the floor or its covering. Chairs should be of such design and slope of back and

seat as will permit a restful poise of the body weight in good position without tilting them. The comfort of a rocking chair and the irresistible tendency to tilt an ordinary chair on its back legs give a clue to the essentials of a restful seat. A few libraries of the better sort are provided with chairs having low seats and backs in which one feels no inclination to get his feet on another chair and balance himself on the rear legs of his chair in that precarious position with which all men are familiar.

Special classes for defectives. In rooms for subnormal or ungraded classes it is usual to make use of movable desks. Groups are small and instruction is largely individual or in very small, shifting groups. Not much of the work is of the sort involving sustained concentration, and there is little of large group activity. Seating should be stable though movable. In classes for the blind it is desirable that furniture should be stationary so that pupils may readily learn and adapt themselves to the arrangement of the room. Lighting conditions, of course, are negligible. But in "sight-saving" classes, for those with defective but not totally lost vision, illumination is of fundamental importance. The writer has visited classes for these unfortunates in which movable equipment was provided but in which absolutely no attention was given to placing it to secure the best illumination of the reading matter or to avoid glare in the faces of the pupils. Not only should the principles of visual conservation be observed in these classrooms, but they should be made a primary matter of instruction and training, taking precedence over all curricular requirements. In classes for the deaf and the near deaf the prime essential is that light should fall with full strength on the face of the teacher so that pupils may see lip movements and facial expression with

perfect clearness. For this reason movable seating should be used and shifted as required, so that pupils sit with their backs to the light and faces squarely to the teacher.

Equipment for crippled children. Seating is a particularly critical and difficult problem in the case of crippled children. Elaborate seats with numerous movable and adjustable parts have been devised with reference to extreme rather than typical cases and are extensively used in many of these special schools and classes. It is now recognized that this is the wrong approach to this problem and that such equipment may do more harm to the many who do not require it than it does good to the few who do. The first principle to be observed is that equipment should be as nearly normal as the infirmities of these unfortunates permit, both for psychological effect and as training for out-of-school conditions. A considerable proportion of them require and should have no special devices whatever. Except for a small percentage of the crippled children, there is but one characteristic difficulty to be

FIG. 58. Cripple in swivel seat lifting his leg, by means of adjustable leg support, preparatory to turning into working position as in Fig. 59. (Stocking School, Grand Rapids, Michigan)

provided for other than those which they have in common with all normal children. This is the difficulty involved in sliding, twisting, or turning to get into a school seat and to get their legs under the desk. The swivel seat seems to solve this problem as perfectly as any device can, since it permits one to sit or rise freely with no obstruction in the way of the stiff leg, and then, if there are no desk supports to interfere, one may turn oneself easily into proper relation to the desk. It must, of course, be possible to enter the seat from either side, according as the infirmity may require. For libraries, lunch rooms, and other places where fixed tables are used, the seats should also be stationary, and for classroom purposes the seat should be in fixed relation to the desk, the aim being to avoid the necessity of hitching the chair up to the desk. Movable seating is preferable for classroom use, but it is very important that it should be stable enough not to overturn or slide away from the pupil when he uses it as a support in sitting or rising. Rubber crutch tips on the feet of the

FIG. 59. Cripple in movable and adjustable desk with swivel seat equipped with adjustable leg and foot support attachments. (Stocking School, Grand Rapids, Michigan)

furniture effectively eliminate the latter danger. A fairly small proportion of the pupils should have a comfortable leg rest attached to the seat and so devised that the pupil can, without assistance, adjust it to any required angle and change the adjustment from time to time to the most comfortable position without the necessity of rising from his seat. In some cases an adjustable foot rest may be equally or more desirable. It is particularly important that those with stiff legs or who are wearing leg braces should not occupy seats which are too deep, since this involves a hip strain even if it is not directly painful to the affected limb. To meet this difficulty, squares of about six inches are sometimes cut out of the front corners of the seat and hinged with some device to support them at any desired angle. It is probable, however, that if the seat is reasonably short and comfortably formed, a leg support is better for the purpose for nearly all cases.

FIG. 60. Adaptation of back support for hunchback. By lowering one slat and substituting for the other a strip of webbing with suitable pads this unfortunate was enabled to relax comfortably against a support which did not throw him out of poise and aggravate his infirmity. (Christopher School for Crippled Children, Chicago)

There are a few cases of stiff hips in which long braces permit of no flexing of the hip whatever. There is no way in which these individuals can sit in position to work at a desk except by having both seat and desk elevated so that the stiff limb can extend straight down. For these it is necessary also to have one side of the seat cut away and to have a foot rest for the sound foot, in order that they may be able to sit in comfortable relation to desk and back support. These cases are rare and are best provided for by mounting a desk with swivel chair, cut as may be necessary, upon a specially made platform. For the spinal cases it is likely that rigid back slats should be replaced by variously shaped or flexible supports. Subject to medical prescription for individual cases, a convenient device is merely to remove the back slats and substitute a fabric band which can be laced to any degree of looseness, and probably to supplement this with small pillows or pads which can be attached in various positions as desired. There remain the wheel-chair cases and other extreme disabilities for which no provision can be made except by special prescription of the physician in charge.

CHAPTER XX

MATERIALS AND CONSTRUCTION

Quality in construction. Aside from its hygienic excellence and educational adaptability, apart from its sanitary finish and æsthetic design, school seating, in common with all furniture and most other manufactured things, varies enormously in value according to the materials, care, and skill used in its manufacture. It is much cheaper to imitate a high-grade product than to make one, specious advertising and persuasive salesmanship are much more readily available than manufacturing equipment and experience, and impressive claims of hygienic superiority are easy to make (though hard to verify). Hence the market is always flooded with a host of school-seating products making equally pretentious claims for public patronage and of equal value so far as hasty inspection of made-up samples by unskilled inspectors can determine.

Buying by chance. To make matters worse, purchases are commonly made not by an expert buyer who has carefully studied all the factors of requirements, values, and costs, but by a majority opinion of a group of men (experts in any subject but this), and based on a hurried inspection of samples after the fatiguing attempt to compare a confused mass of competitive bids. No merchandising or industrial concern would purchase its materials in this manner, nor long survive if it did so. When competitive bids are called for by shrewd purchasers, it is on

the basis of specifications that definitely fix qualities and materials and the things which are comparable as to costs. Competitive bids are accepted in school furniture, and contracts are let on the basis of low price, on specifications which indicate only such obvious things as size and type but are silent on the things that make the differences in cost of construction and values of the product.

Reliability a guaranty. There are concerns in the school-desk business who purchase their wood parts in job lots from planing mills and their metal from foundries or from structural-steel contractors. They may or may not do their own varnishing and they may or may not have their own warehouse, in which their products are assembled. Their business consists in advertising and in taking orders, filling these as they can. Samples are polished until they appear, and possibly are, like high-grade furniture, and, of course, the illustrations that advertise them may be made to look like anything one chooses. The design may be some new idea, possibly good but untried, or it may be borrowed from any successful types, or it may be a "freak" which has been rejected by the reputable manufacturers.

There are other concerns with millions invested in their plants and machinery and with organizations of specialized laborers and distributors which it has taken generations to build, who have unlimited facilities for producing furniture of the best grade and enormous responsibility for maintaining their reputation. There are innumerable differences of material and niceties of construction which these manufacturers employ in their products of which the layman is wholly unaware, which add considerably to costs and enormously to values, and which the jobbing

or assembling concerns without equipment or experience could not provide at any price.

It is not the intent of this chapter to advocate patronage of large, rather than small concerns, and it is superfluous to say that responsibility and experience are the best guaranties of unseen values in any product. On the whole, small and even irresponsible producers have a wholesome effect on the trade, since they compel those who have most at stake to depend on reliability and reputation for their continued dominance. There is urgent need, however, in behalf of the public welfare and the protection of children and school funds, of more definite standards of quality so that a board which accepts a low bid will know just what is being sacrificed for the saving in cost, and one which pays a higher price will know just what it is getting for the extra outlay. The purpose of this chapter is to indicate some of the more important factors of structural excellence with a view of setting up at least some standards of value. With questions of design and proportions, which are of first importance in school hygiene and educational efficiency, we have dealt in the preceding chapters. Here we are confined to questions of material and construction.

Wood or metal? Until the advent of the "patent school desk" two or three generations ago, wood was regarded as the only suitable material for the manufacture of furniture. Within the past two or three decades iron and steel have so far supplanted wood that now nearly every kind of furniture can be found constructed wholly of steel — notably beds, wardrobes, bookshelves, kitchen tables and cabinets, lockers, and every sort of office, laboratory, and hospital equipment; while practically all theater and school seats and many other kinds of

furniture have steel or cast-metal standards. Metal has unquestioned superiority in strength, durability, and sanitary qualities; it is capable of construction into a far greater range of forms; it is impervious to climatic changes of moisture and temperature, which cause wood to split and check, to shrink and swell, and to work loose at the joints; it is fire-proof and offers little attraction to mischievous knives. With methods of production constantly improving, steel constantly becomes better and relatively cheaper, whereas progressive destruction of forests is making the better grades of wood much rarer and more expensive. Steel construction, however (and to a less degree that of lower-grade iron), is economical only in quantity production. Very expensive presses, dies, jigs, and other machinery or patterns are necessary for metal construction, whereas only a planing mill and carpenters' tools are necessary for more or less successful woodwork. This expense of construction makes for standardization and conservatism as to new ideas on the part of manufacturers in metal. It also makes for centralization of the manufacturing, with higher specialization of technique in the industry, more widespread and elaborate selling organization, and transportation over greater distances in distributing. Metal construction, again, is more favorable to wide distribution from central manufacturing points, since it permits of knocked-down construction and of more compact and much cheaper freighting.

It has usually been supposed that there are certain parts of furniture in which wood can never be supplanted by metal, but one after another these limitations have been overcome, and now table tops and occasionally seats and backs of furniture, as well as all sorts of drawers and framework, are made of steel. Steel surfaces are

thought to have a sanitary superiority for hospital and kitchen uses, but are regarded as cold and disagreeable and perhaps unhygienic for school equipment and general use.

A primary claim of wood for retention — at least for such parts as are most in view and in contact with the person — is its essential beauty and attractiveness. Even the most perfect "graining" on metal looks to be what it is — a superficial imitation of the inherent natural beauty of wood. It wears off with the finish and leaves an offensive impression of cheap make-believe. If metal should ever replace wood where beauty is the consideration, it will be by the development of an essential beauty of its own and not by any shoddy imitation of wood. Wood is in no danger of being displaced by metal for general use in desk tops, seats, and backs, and a sufficient reason is an æsthetic one rather than a utilitarian. For all supporting framework steel is already established as superior in every practical respect and not inferior in appearance. Certain minor objections, such as noisiness and vibrancy, can be overcome and should be regarded as defects of construction.

Choice of wood. The kind of wood best suited for the contact surfaces of school furniture must be as hard, smooth, and durable as possible. Eliminating from consideration all soft woods and all expensive imported kinds, the manufacturer is practically limited to a choice among oak, birch, cherry, and maple. Of these oak is the most abundant, being in many respects the most attractive and probably the wood most commonly used. The coarse grain, which gives the striking beauty to oak, is, however, its great defect for this particular use. The rays and hard layers give it its great strength and are practically impervious to stain, but between these are very soft,

pithy layers which can easily be indented by a finger nail and which readily absorb stain or moisture. Inferior varnish quickly sucks down into these soft layers, leaving a roughened surface streaked with lines of fine holes and brittle bridges. The finest glassy surface of multiple coats of highest-grade varnish will in time give way, even with careful use, along these fine lines of soft grain. These minute depressions not only make a very defective writing-surface but form a harbor for dirt and germs which is impossible to cleanse effectively and which is therefore quite objectionable for schoolroom use. Cherry is objectionable primarily for its harsh-red color which can be only partly suppressed by any of the customary stains. Neither cherry nor birch have quite the fine grain or wear-resisting hardness of the best maple, and it is for this reason primarily that maple is regarded as the best hard wood for flooring which is exposed to water as well as wear. Being neutral in its own coloring, it readily lends itself to any desired stain and retains a surface finish equal to that of mahogany. Altogether, the best hard maple seems to be the most nearly ideal wood afforded by the American forests for school furniture, with birch as a close second.

Flawless stock. The rapidly increasing difficulty of securing perfect stock in large pieces is making an increasing difference in price between the best select stock and inferior grades. In the best factories only absolutely flawless stock is used for school desks and seats. A number of expert inspectors are kept busy at every stage of manufacturing from the sawmill to the finished desk, and their trained eyes detect every minute knot, split, wind shake, or discoloration. However slight the defects, a large proportion of which are absolutely invisible to any

but an expert, every imperfect piece is thrown out. In this way but a small proportion of the log gets into the furniture, but that little will endure anything which wood can stand. It is needless to say that much inferior stock goes into the making of inferior products.

Built-up wood and ply wood. Modern methods of building up wood by gluing under pressure make it possible to combine comparatively narrow strips of perfect wood into as large surfaces as may be desired, and the joints so formed are as perfect and as strong as the best of the wood itself and are less likely to split.

The use of ply wood also has several important advantages. By virtue of the rotary cut by which the thin sheets of wood are obtained, the ordinary waste of slabs, saw cuts, and strips is avoided, and thus a much larger percentage of the log is utilized. Since in the alternate layers of ply wood the grain is run crosswise, the resulting pieces are much stronger, and splitting is impossible. Equal strength is therefore obtained with much less wood and less weight. Another advantage is that while the ply wood is being glued under enormous pressure, it may be shaped into forms which would be impossible in solid wood except in very thick construction and with extravagant waste. These economies make possible a free use of wood construction at a low price, whereas solid-wood construction would be heavier, would be inferior in strength and appearance, and would soon consume the forest resources to an extent that would make cost prohibitive and destroy the industry. In the making of ply wood, however, superior skill, adequate equipment, and thorough scientific knowledge are indispensable. Poorly made ply wood will separate and peel under the vicissitudes of changing temperature, humidity, and hard

usage, but the best-made is superior to solid wood in almost every respect. In a matter of this kind the standing and guaranty of the manufacturer are the purchaser's only protection.

Modern kiln-drying. Another matter which is extremely important in getting long and perfect service from the wood used, and one of which even an expert is helpless to judge unless he knows the process that has been used, is the curing of the wood. Ancient craftsmen prepared the woods for their masterpieces of furniture by years of slow drying under carefully selected conditions of storage. This is impossible under modern conditions of manufacture. Ordinary kiln-drying reduces the moisture content unevenly, thereby rendering the wood brittle on the outside while it still contains a large percentage of water within. This inevitably results in cracking and warping; and however perfectly the surface may be finished at the time of delivery, swelling, shrinking, warping, and twisting will follow exposure to changes of temperature and humidity. No mere wholesale routine methods of drying can avoid these tendencies, since the moisture content and the readiness with which it is surrendered at varying depths from the surface vary with the texture of the individual trees, with the seasons and weather, and other known and unknown factors. Perfect drying requires a certain period of weather exposure. The amount of this exposure is determined for each lot separately by repeated measurement of water content and physical condition. The lumber is then placed in the kiln in a bath of steam to prevent surface-drying as the heat gradually reduces the moisture at the center. Samples are cut at intervals of a few hours and are tested with scientific accuracy to determine the precise water content at all

depths, and the heat and the steam are regulated with reference to each other and to the conditions of the samples so that the wood is actually dried from the inside outward until the desired condition is perfectly attained. Scales which will weigh a hair, and a bewildering array of graphs and calculations, are employed by the scientist who directs the kiln-drying, in order to keep a record of the moisture elimination of each lot of material in each section of his kiln. Nothing is left to chance or guesswork. When the boards are turned over by him to the manufacturing department, carefully regulated conditions of heat and humidity must be maintained in storage and operating rooms until the final coats of air-proof and moisture-proof finish have been applied and the moisture content of the piece is fixed for all time almost as definitely as is that of its steel supports. Such preparation is expensive, but nothing else can insure the qualities which are essential to high-grade, enduring furniture.

Finishing operations. The difference between cheaply made and high-grade furniture is discernible in the sharp edges and corners and occasional rough spots on the surface of the products. These differences are important enough in themselves, but often more so as indexes of care in unseen things. Numerous distinct machines and operations and a surprising number of sanding and other smoothing operations are involved in these apparently slight differences of finish. Of course, a sample may be finished to any degree of perfection by hand, but it is when such refinements appear in stock goods that they are a fairly safe index of the care and skill with which the product is made.

Varnishes. As everyone knows, the varnishing has a great deal to do with the satisfactory service which any

furniture, especially that subjected to the hard usage of the schoolroom, can render. This is another element of value at which the layman or even the expert without elaborate tests can only guess. It can to a large degree be standardized so that a direct statement of the materials and methods used would fairly fix the quality of the finish for purposes of comparison. This chapter does not attempt to indicate any such standards but merely to make certain relevant suggestions. A good finish for school desks usually implies, first, a suitable stain which will produce the desired color in the finished product but which contains no elements to affect subsequent coats deleteriously. There must then be a hard surfacing or body coat of superior shellac. This must be sanded to a smooth finish. One or more coats of the best varnish are then applied, each being carefully dried and sanded before the next is applied. So far as we know, no effective way of dipping woods in varnish or baking the finish has been developed, and hence these successive hand-brushed coats are expensive, and the price of the product will be materially affected by the number of coats. The hardest and most nearly indestructible varnishes at present are made from kauri gum, a petrified resin found only in New Zealand and neighboring islands, the lumps used for commercial purposes being found buried in the sands. This gum is impervious to almost all acids, oils, and other substances which are likely to come in contact with it, and the better varnishes made from it are usually affected only by actual mechanical bruising.

While many preparations sold under the name of lacquer have many grades of excellence, the best quality is that now being increasingly used for high-grade automobile finish. This finish is absolutely impervious to

moisture and may be boiled in water without injury. It resists the action of practically all acids and chemicals to which furniture is exposed; it cannot chip, crack, or peel; it is so elastic that it is not broken by denting the wood; and it is harder than any wood surface. The fact that it may be cleaned with hot water and soap or with any chemical disinfectant is an important sanitary value. The difficulty is in applying it in a practical manner, since it cannot be brushed on nor can it be sprayed while exposed to the atmosphere without serious loss of the material. Finishes purporting to be lacquer may readily be tested with hot water, ink, acids, and by bruising.

Cast metal. The metal used in the construction of school desks may readily be classified into three kinds: cast, bar, and sheet (or pressed) steel. The earlier "patent desks" were all made with cast-iron standards, and these are still extensively made and sold. Cast-metal desks hold a place in the market primarily because of their cheapness. They are necessarily heavy and relatively very brittle. Freight charges are high, breakage is serious in shipping and handling, and after installation breakage is considerable unless they are very sturdily built, especially in the foot attachments and the seat hinges and supports. Surfaces are rougher, and even when smoothed with a heavy covering of enamel do not have the attractive sanitary finish of steel. Unless very carefully made and inspected they are likely to have occasional sharp edges, or "fins." To avoid these the better-made articles are ground along all edges, finished with hand files, and inspected with the greatest care. The cast type of construction is best adapted to job-lot production, since the only special equipment required is the pattern, which may be used in the molds of any foundry. The quality of

the casting varies with the particular formula of the metal used, the highest chemical knowledge and most careful analysis being necessary to secure the precise alloy best adapted for each type of casting. "Semi-steel" is a name applied to some particular formulas, but no one formula is best for all types of castings. Excellence also depends on the skill of the molders and particularly on the thoroughness of inspection and a policy which rejects instead of hiding the inevitable defects. Cast metal is regarded as superior for theater and auditorium chair standards because it lends itself to special architectural designs. Its weight and brittleness are not objectionable for this purpose, because this furniture is never moved and, being set up in rows of several seats, is not subject to the strains which individual units must stand. The danger point which must be guarded against is the hinged seat support.

Structural iron. Construction of structural bar iron most commonly uses ordinary stock angle-iron, though T, U, strap, or gas-pipe stock may be used. This material is much tougher than cast metal and will usually bend before it will break. Machine-shop equipment of saws, punches, jigs, bending presses, and the like is necessary to avoid handwork, which would be prohibitive in cost. Such equipment is expensive, but as little of it, if any, needs to be specially constructed, manufacturing in this material can be done in job lots in shops doing a general business. Material of this type is produced in enormous quantities by rolling-mills for structural purposes and hence lacks the fine finish which is desirable in high-grade furniture. Joints are usually crude, since very expensive grinding operations would be necessary to round them off smoothly. If fastened with bolts they are liable to

work loose either with or without the assistance of mechanically minded meddlesome boys. Riveting, also, even when done by experts and inspected with greatest care (which is expensive), will leave on rigid material of this sort a certain proportion of joints which are, or soon become, loose. Welding is much superior if properly done. The uncertainties in welding will be mentioned in connection with pressed-steel construction, but the chances of a good job are much less in bar construction (1) since the material is much heavier and more difficult to weld; (2) since it is of relatively low-grade iron with many impurities, especially on the surface, and hence perfect fluxion is often impossible; (3) since this material is used in cheaper construction, there is not the same care and expertness devoted to the work. The range of bending and shaping which is possible in this type of construction is quite narrowly limited if the stock used is sufficiently heavy to insure permanent rigidity of the furniture. Many operations are involved, and this increases the uncertain "human factor" and means greater uncertainty of product in rapid quantity production. To provide sufficient rigidity at the few points of great strain, it is necessary to use heavy stock at many points where it merely adds to weight and cost.

Pressed steel. Pressed-steel, or sheet-steel, construction represents the most advanced type of metal-furniture manufacture. This material is made from high-quality metal and hence has greater strength with far less weight than either cast metal or bar metal. In designing, any amount of strength may be provided at the points of, and in the direction of, great strain and eliminated where it serves no useful purpose. The metal, being pure and thin, lends itself to perfect electric welding. A good weld

requires that the metal of both pieces be completely fluxed at the point of contact and unite in a joint as strong as the metal itself. The test of perfect welding is that if sufficient force be applied to break the joint apart, the welded portion will tear out the metal round it before it will itself give way. This is the standard actually attained in the best factories, but it requires a high degree of skill and superior equipment. It involves a highly technical adjustment of electric points and current to insure that the heat will develop precisely at the point of contact instead of unevenly in the two parts. The perfect welding upon which the strength of the whole depends is one of the surest indexes of thoroughness in construction. Sheet metal has a great advantage over bar metal in that it may not only be bent into any sort of bar, angle, or tube desired but may also be used for panels and other flat parts. Joints may be concealed in the designing or finished to any degree of nicety in the manufacturing operation. If bolts or rivets are used, they may hold the two surfaces together with a "live," or tension, contact (like that obtained by using a split washer on an automobile), which reduces the probability of defective connections and prevents their working loose. If the feet are properly made, they also have this live attachment, which prevents screws from working loose in the floor, and the feet may be made to fit to the floor with a waterproof and dirt-proof contact that greatly increases the life of the floor as well as the life of the desk. These conditions cannot be attained with either cast-iron or bar-iron structure. In bar-metal construction, differences in size of stock between one part and another, which are necessary to secure strength without undue clumsiness, are always apparent at a glance and usually prevent

well-formed joints. Sheet steel, however, of various weights may be combined as desired — heavier-gauge stock in the standards and lighter in the panels etc. — without any sacrifice of uniformity in appearance or any resulting crudities of finish. The gauge of the steel used in the supporting members is a very important factor in the strength and rigidity of the furniture. The best desks are made with twelve-gauge to sixteen-gauge stock for these parts, but light twenty-gauge is used in some lower-grade products. The saving in cost in the use of lighter steel is not so much in the cost of the steel itself (though that is considerable) as it is in the machinery and operations required for the shaping of the heavier steel. Only factories with very superior and expensive machinery can make use of the heavy-gauge stock. The gauge of the pressed steel used in supporting members is a fair index not only of the strength of the desk but also of the manufacturing concern which is behind it. Another large factor in strength and permanent rigidity is the form into which the steel is shaped. It is well known that the greatest possible strength for a given weight of material is attained in a closed tube, but it is obvious that such a shape requires far more elaborate machinery and operations than a mere flange or stiffening angle.

The necessity of using these enormously powerful presses, rolling machines, and very expensive dies is the limiting factor which prevents the more extensive use of pressed-steel construction. It is practicable only in large-quantity production of completely standardized products. Slight changes in the design of cast or bar construction involve relatively trivial alteration of the equipment, whereas to change any dimension even a fraction of an

inch in pressed steel will often involve an expenditure of thousands of dollars and perhaps weeks or months of the time of the highest-priced designers and die makers. For such reasons steel construction must be stable and conservative. Changes cannot be made to suit the individual ideas or whims of purchasers. To survive at all, a concern engaged in this type of manufacture must give a great deal of attention to getting its standardized product so nearly right that vast quantities may be produced before changes are required. This very fact is one of the guaranties that the purchaser has as to the stability and size of the producing organization and as to the care with which its products have been designed.

Sheet steel, because of the ingredients and methods used in its production, is almost entirely free from defects which can affect its appearance or serviceability. In this it has a great advantage over either cast iron or bar iron. Its smooth surface admits of the highest grade of enamel finish in a smooth, uniform coat. This enamel is baked on and gives a beautiful, sanitary, and durable finish impossible to the crude surfaces of low-grade materials. The best grade of this enamel is so elastic and so nearly indestructible that a piece of steel thus treated may be bent double back and forth again and again without developing the slightest crack or defect in the finish. Nothing but a sharp instrument forcibly applied or heat which would destroy the building will affect it.

Attaching wood to metal. The attaching of wood parts to metal offers certain peculiar difficulties owing to the fact that metal expands with heat and contracts with cold, while wood (unless perfectly kiln-dried and surfaced with moisture-proof finish) expands with humidity and contracts with dryness. The hot, dry atmosphere of the

schoolroom tends to expand the metal at the same time that it contracts the wood. Even the most perfect construction cannot eliminate the expansion and contraction of the metal or entirely eliminate that of the wood. Hence, in inferior construction the metal actually pulls the wood apart. This is provided against by the use of various serpentine and other tenon devices for holding the desk top to its supporting metal with but a single fixed screw attachment. Where this is impracticable, screws are inserted through elongated elliptical holes which permit the necessary sliding. These provisions may be unnecessary if the wood is thoroughly prepared and its relation to the metal thoroughly studied.

CHAPTER XXI

ON THE BUYING OF SCHOOL DESKS

The value of a desk. Garfield's famous quip that the best university would be a boy on one end of a log and Mark Hopkins on the other, would have more point to it in these days of universal education if only there were a Mark Hopkins available for every boy, or even enough logs to go round. The typical schoolboy must get on as best he can with about one fortieth of the attention of such teacher as he has and with a very small fraction of a log. The teacher-statesman's meaning was, of course, that Hopkins would have been a great teacher in spite of crude equipment and not because of it. In fact, he used the best equipment he could get. No one can doubt that the first requisite of a good school is good teaching, and the primary claim of superior equipment for consideration is that it helps to make teaching better. There is no more a problem of choice between teacher and equipment than there is between a good workman and good tools for him to work with. Either is a good investment which goes largely to waste without the other. The cost of equipment is so trivial compared with other expenditures for education that if it can increase the efficiency of teachers and building by any appreciable amount, it is an enormously profitable investment. Though figures mean little in such connection, we may get some conception of relative values of equipment if we assume that one sort increases the teacher's efficiency more than another sort

by 10, 5, or even 1 per cent. The difference in value between the two kinds of equipment, then, is 10, 5, or 1 per cent of the cost of teacher and plant for the entire duration of the life of the equipment, an amount which would be many times the whole cost of any equipment on the market. And this without any consideration of the hygienic differences which, as we have seen in the preceding chapters, may affect the lifelong happiness and efficiency of each generation of the pupils which use it. Questions of educational and hygienic values so far outweigh questions of cost in seating equipment that one does not seem justified in discussing the latter where the former are involved.

Community investments in self-respect. There is an aspect of the matter distinct from these which deserves consideration. Every school board in its building-program makes a large expenditure of community funds in community pride and self-respect. Aside from a mere safe and sanitary shelter for the educational industry, such as a factory building might afford, the modern school building is a monument to the community's aspirations, faith in its future and in education as the chosen means of lifting each generation above the preceding one. A large part of the cost of the building is invested, and very wisely so, in architectural beauty and dignity, in refinements of construction and finish, to which citizens point with growing civic pride and from which children derive a subtle but no less genuine educational influence making for character and good citizenship. But the imposing façade that his father points out to an occasional stranger, or the corridors and auditorium through which the principal ushers the yet rarer visitor, have a relatively slight influence upon the pupil, who hurries through them

a few times a day, as compared with the desks, which are directly under his eyes and in contact with his hands during all his working hours. Under the architect's inspiration the board may provide a magnificent building, but its effect on the child is largely destroyed if, for the saving of a few dollars, it is equipped with crude and misshapen furniture or with the disfigured and unsightly relics of a former generation moved over from the condemned building which they have outlived.

Refinement. Next to the clothing he wears, nothing in the life of a child comes so continuously and insistently in contact with him during his waking hours as does his school desk; nothing more surely impresses upon him its tone, refinement, and standards of quality. Business men recognize that clean linen and good clothing are wise investments, aside from the greater service they give and the respect they command from others, because of the self-respect they engender. Cleanliness, good taste, and refinement in one's immediate environment and personal contacts somehow strike in and impose an irresistible stimulus to live up to them. For this reason good teachers (and parents) train children in ideals and habits of neatness. The clean, neatly clad child sits better, speaks more accurately, and behaves better than the ill-smelling, grimy one. No one who has not observed it can appreciate the new zeal, class pride, and improvement in conduct and standards of work which result from replacing a lot of soiled and rickety desks with an installation of attractive, well-finished ones. The tone of quality and refinement which emanates from the seating of a schoolroom, even more than that from its walls and exteriors, is reflected in the immediate attitudes as well as in the permanent standards of the pupils. These subtler values

are as worth while in community education as are the higher refinements of accuracy in spelling, skill in penmanship, or facility in calculation and reading.

The cost of a desk. The cost of an average school desk, say eight dollars, when spread over twenty years (which is a low estimate for its life of service) is but one cent a week. The whole expense of a child's education will average approximately two dollars a week. Surely if there is any discoverable difference in hygienic, educational, or æsthetic values between two desks, a matter of 10 or of 100 per cent difference in initial cost is not worthy of consideration. Even this original saving may be deceptive, since the cheapness of a desk may be an indication of inferiority in construction and hence a forewarning of more frequent breakage and rapid deterioration. Decreased cost of upkeep, increased life of service, and, particularly, a longer period of refined and attractive appearance are as truly cost economies as is low price. These platitudinous observations would be inexcusable if it were not a fact well known to school administrators and to the school-furniture trade that the low bid is still one of the strongest arguments and often the decisive factor in the sale of school equipment. Business men who would regard mere cheapness as a matter of suspicion in purchasing a suit of clothes or furnishings for their own homes do not hesitate to close a contract for school furniture on a basis of low bid. This is the more surprising, since school equipment is a relatively permanent investment on a comparatively large scale and financed by a large and permanent institution, the community — just the sort of investment which should be on a sure and conservative basis rather than on one of temporary expedience.

Unwise purchase of school seats. The explanation of this situation is threefold. First, the board very frequently is faced with the necessity of supplying a definite amount of equipment from an inadequate remnant of a building fund. Choice is reduced to dividing a small number of dollars available by a large number of seats required. Secondly, there are no standards by which a layman can determine genuine values. Salesmen's claims and samples look pretty much alike to the board member, and the only difference that he can clearly recognize is expressed in dollars and cents. Thirdly, by the time equipment is purchased, the board members have been wearied to the point of exhaustion by repeated and protracted meetings with superintendent, council, legal advisers, architects, contractors, committees, delegates, and complainants of every sort. They have given generously of time and energy to serve the public interests, usually without compensation and with much criticism and no little sacrifice of their private concerns. It is not surprising that the shortest and simplest solution of this last problem should seem the best or the only one. Cynics, who are always suspicious of those in authority, would add a fourth explanation, questioning the integrity of those who expend public funds. We believe such cases are rare, generous self-sacrifice being far more common among school-board members than dishonesty.

Separation of funds imperative. The remedy for the first situation is found in separate budgets for building and equipment. A small and relatively fixed item to receive attention last is easily lost in the same budget with a large and uncertain one which has prior attention. The most experienced architect cannot guess with anything like accuracy as to the cost of the building which he plans.

As is well known, contractors' bids may vary as much as 50 per cent on the most detailed specifications. Almost invariably there are alterations and improvements to be made after the contracts are closed and work is under way. These cost money. It is rarely indeed that the final cost of the building does not exceed estimates and expectations. These additional costs must be paid out of any equipment reserve which may be in the fund, with the result that that reserve is usually inadequate and often becomes an overdraft. Worried with an unexpected deficit and compelled to find some means of getting equipment out of maintenance, repair, or other funds, it is not surprising that wearied boards cannot be interested in seating ideals beyond minimum essentials at minimum prices. Usually they are frank to say so. Many are the handsome new buildings throughout the country disfigured by cheap, ill-shaped seating or by the battle-scarred dilapidated desks which are moved from old buildings. The inspiration of the architect is killed for the child by direct contact with uncomfortable and unsightly desks. Experienced school officials have learned that the only way to avoid this confusion in finances and this anticlimax in enthusiasm is to keep building and equipment funds separated. It is often better to have separate bond issues or levies so that people who vote for a hundred-thousand or a million-dollar building will realize that they are thereby assuming an additional investment for equipment; or if the round figure is to cover both purposes, the division should be publicly indicated so that there will be no ugly rumors about that last ten thousand or fifty thousand that was not paid for the building. In any case a fair estimate for furniture for the number of sittings to be provided can be made by the

time that the architect can complete his plans. This amount should be separated absolutely and inviolably from the building fund. Let the expenditure for each purpose be kept absolutely within its own budget; or if either exceeds the provision for it, let the deficit be met independently without encroaching upon the other. If plans are to be revised downward or appropriations to be revised upward, let each part of the fund stand upon its own responsibility. Thus financial problems are enormously simplified and untold misunderstandings, worries, and recriminations avoided. There may also be unforeseen but necessary expenditures for equipment after the school opens for business; hence it is not safe to transfer a supposedly unrequired balance from either one of these funds to the other until the final closing of each account.

Coöperative planning. With positive knowledge of what the equipment budget is to be, the educational force can begin, as soon as the architect's layout of the building is available, to plan the furnishing; to study in detail the available designs and devices; to obtain, analyze, and criticize proposals from competing supply concerns; to compare display samples with actual installations; to test salesmen's claims with the proof of classroom use; perhaps to visit factories and study methods and thoroughness of construction. Committees of teachers and supervisors will have opportunity to investigate new ideas in equipment, to distinguish between improvements and fads, to make matured recommendations, and to obtain, through such preparation, the highest values from whatever may be selected. The administrative force will have opportunity to check these recommendations in the light of riper and broader experience. Departments will have opportunity to get together on

conflicting claims and to decide on the cutting of these to the limits of the budget. Just how much participation of the teaching force in these matters is desirable may be a debatable question, but the point is that the separate budget makes possible any investigations desired. So long as the most carefully prepared recommendations may be subjected at the last moment to a cut of 25 or 50 per cent because of deficiency in the fund, or so long as it is anticipated that they may be so cut, nothing constructive can be expected. If the board desires coöperation they must set some basis on which to coöperate.

Unhurried buying. It is also very desirable that contracts for equipment, particularly in large lots, should be placed as early as possible. The school-furniture business has long been a highly seasonal and therefore wasteful industry. Factories have closed down or run on a skeleton organization during several months of the year and then worked overtime with a hastily gathered crew of untrained labor, turning out desks in any fashion to fill orders during the rush months before the opening of schools in the fall. Well-made furniture cannot be produced under such conditions, nor can such as is made be produced economically. Uniform, year-round production, continuously utilizing a well-equipped plant and a stable organization of experienced operatives, is essential to the production of high-grade goods with reasonable economy. Consumers must always pay in one way or another for idle plants and disorganized factory forces. Only the manufacturers having great financial resources and enormous storage and distributing facilities have been able to stabilize this industry, which purchasers have made so highly seasonal and uncertain. Even these cannot absorb all the fluctuations of erratic buying and are

frequently forced to decline last-minute rush orders, leaving the harried procrastinators at the mercy of irresponsible jobbers and order takers. It takes months to convert trees and iron ore into good school desks. Delays from breakdowns, strikes, or transportation troubles cannot be foreseen. Guaranties against delays are either worthless or very expensive unless the goods are actually ready for delivery. Early ordering backed by a distinct budget relieves the purchasing board of all anxiety about having the seating in place as soon as the rooms are ready to receive it and gives them every advantage in the matter of prices and terms. Foresight in purchasing raises the standard of the industry, while procrastination helps to keep it on an uncertain and irresponsible footing.

The fallacy of competitive bidding. Methods of purchasing have been particularly unwise. The most common method is the issuing of "specifications" upon which sealed bids are invited by advertisement or otherwise. At the time appointed for the opening of bids the board or its committee assembles (often in "open" meeting attended only by competing salesmen), and the bids are tabulated. The board then inspects samples and awards the contract. This may be a wise method of awarding a contract for a building or for paving on the specifications of an architect or an engineer, but it is certainly not one which would be pursued by an industrial concern in purchasing machinery and supplies, or by a mercantile concern in buying stock. The first trouble with the plan is that specifications do not specify the factors which are comparable either as to value or as to price. They ordinarily indicate merely the number of desks of each size and the general type, such as "500 No. 1 combination desks." Sometimes they designate a particular make "or

equivalent." The whole question of price equality is in the matter of *equivalence*, and of this no one but an expert, after study, can be a competent judge. It is a foregone conclusion that price should be purely a matter of quality if bidding is on a responsible, businesslike basis. No reliable manufacturer or dealer will offer his product for less than its established sales value. The low bid should always be and usually is on the cheaper goods, whatever the sample may be made to look like. Any other condition must mean that the seller of the cheaper article is charging more than his goods are worth or that the better article is being sold for less than its cost. Either situation is reason enough for throwing out a bid if only one could know what situation he is facing. If prices were determined by values, the high bid in school furniture would be the best buy; if not (and that is the assumption in calling for bids), the price bid has no relation to the desirability of the purchase. In the case of the building, where there is a very large element of chance in costs, where the supervision of architect and inspector are the guaranties of proper construction, and where specifications indicate the bases of value, there is a reason for taking the lowest responsible bid. Each building sets its own standard of quality. In manufactured articles, such as clothing, tools, typewriters, or school seats, quality is determined for each make or brand long in advance of the placing of a particular order. Reliable concerns exist by means of their reputations, and these depend on their policy of systematically giving quality commensurate with the price they charge, or of cutting the price to the quality they give. The policy of sealed bidding on specifications, which, by the very nature of the thing bid upon, cannot specify the elements of comparative cost or value,

is always an advantage to the irresponsible bidder and cheap article. Manufacturers of high-grade goods frequently refuse to bid under such conditions. The only chance they have for the business is to convince the board, either before or after bids are opened, that there is enough difference in values of the goods to justify the rejection of the lower bids, in which case the whole business of receiving bids is a farce, and boards are subjected to criticism and suspicion for not accepting the low bid for which they asked.

Selections by the school board. If the board members do not know the relative values of the competing desks before the hasty inspection of samples which follows the opening of bids, they certainly do not know them after it. They may or may not be able to detect some of the indications of superior or inferior material and construction. They most certainly cannot judge of the hygienic proportions or design by looking at or "trying" a seat. The majority do not have any independent judgment in the matter, but are guided by one or two leaders, and these have formed their judgment upon that of the superintendent or other educator in whom they have confidence, or because of their friendship for, or confidence in, the salesman who represents some line. In short, the final judgment depends in a haphazard, indirect manner upon just what it should have been based on, frankly and openly, from the first; that is, acceptance of professional opinion and confidence in the manufacturer or dealer. The actual selection, however, is so tangled up with the formalities of meaningless bids and restrictions that it frequently goes where no one, except the successful bidder, really desires it to go. School-board members in general represent the best professional

and business types of the community. They are usually honest and throw about themselves the device of sealed bidding largely to protect themselves from charges of dishonesty or partiality, or it is imposed upon them by archaic law. The scheme looks fair and effective for getting low prices. In operation it is often unfair and is effective for getting low qualities. Board members may be experts in any line except one — school furniture. Expertness in this line would disqualify one from serving in the selection of equipment because of his presumable personal interest. Yet the very policy of taking competitive bids is based on the supposed competency of those who pass upon them to judge of the quality and "equivalence" of the articles offered.

Expert buying in an open market. There is a perfectly simple and obvious remedy for the whole awkward situation — one that has long been followed by practically all large commercial and industrial organizations in the purchase of similar commodities, and one that is now rapidly replacing the competitive bidding in well-organized school systems: purchasing in the open market by expert buyers. An expert is one who knows thoroughly the kind of goods needed, the materials and methods of construction embodied in the several standard products on the market, the responsibility of the various dealers and manufacturers and their capacity for executing contracts reliably, the suitability of designs and dimensions in the different types and makes offered, the genuine values which are in the goods, and the prices which are fair and equitable for each. He knows what is wanted and how to get it to best advantage, allowing a just profit, without which manufacturers or dealers must be either irresponsible or dishonest. The better class of

American business is thoroughly committed to the "one-price policy," plainly marked and advertised, particularly on goods which through quantity production are standardized in quality and values. It is a misfortune that the prevailing competitive-bidding policy of most school boards has prevented the school-desk business from getting squarely on this basis, and the sooner intelligent buying gets it there, the better for the schools and for the industry. It is a strange commentary on the situation that many boards, although still going through the cumbersome and embarrassing formality of receiving competitive bids as a matter of tradition or perhaps of archaic law, are actually making their selections on the advice of educational specialists, who thus function practically as expert buyers. Selections should be made carefully, scientifically, and deliberately, all open and aboveboard, by a competent expert who is at all times openly accessible and who is held accountable for fair and economical purchasing. The board, of course, may reserve the right to pass upon special large items or upon budgeted recommendations as a whole. Secret bidding makes for sharp practices and furtive methods. It makes selling a game of chance instead of a sound business.

The need of experts. Many boards do buy through purchasing agents, though the children in school are suffering because some of these agents lack in knowledge of, or competent advice in, matters of seating. Indeed, the difficulty has been the lack of those competent to qualify as experts in this matter of seating. It has been a no-man's land, belonging neither to architect, to business management, nor to educational department, yet more or less claimed or avoided by all. (In the multiplicity of ignorance there is little wisdom.) Someone in the school

systém should be charged with the responsibility of becoming an expert in the matter of seating and equipment. He should be in touch with the medical and physical-culture departments and know what makes school desks hygienic or otherwise. He should be in close contact with classroom problems of teaching and management and have sufficiently wide experience to know educational values from educational fads in seating. He should know the varied requirements of the several grades and departments and know the best practices in each as well as the standard practices. He should know the differences in material and construction which make differences in value and price. He should know the facilities and standing of manufacturers and know to what extent a name represents superiority of quality or design. He should keep track of the market and know when and how to buy to the best advantage. He should be an expert buyer, capable of meeting on an equal footing the expert sellers with whom he should deal.

It is hoped that this book may contribute at least a little toward a systematic body of information which practical experience and further study may develop into such expert knowledge. It will have been well worth while if it aids at all in putting the making, selling, and buying of school seats on the highest possible plane of public service.

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